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THE Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 900 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

	Initiation Fees		*Annual Dues*
Members	$ 5.00	Members	$ 5.00
Juniors	1.00	Juniors	1.00
Associates	25.00	Associates	25.00
Corporate Members	10.00	Corporate Members	10.00

This Association has at least eight regular meetings each year, of which five are held in Boston, one in northern New England, one in southern New England, and one, the annual convention, held in September on such date as the Executive Committee may designate.

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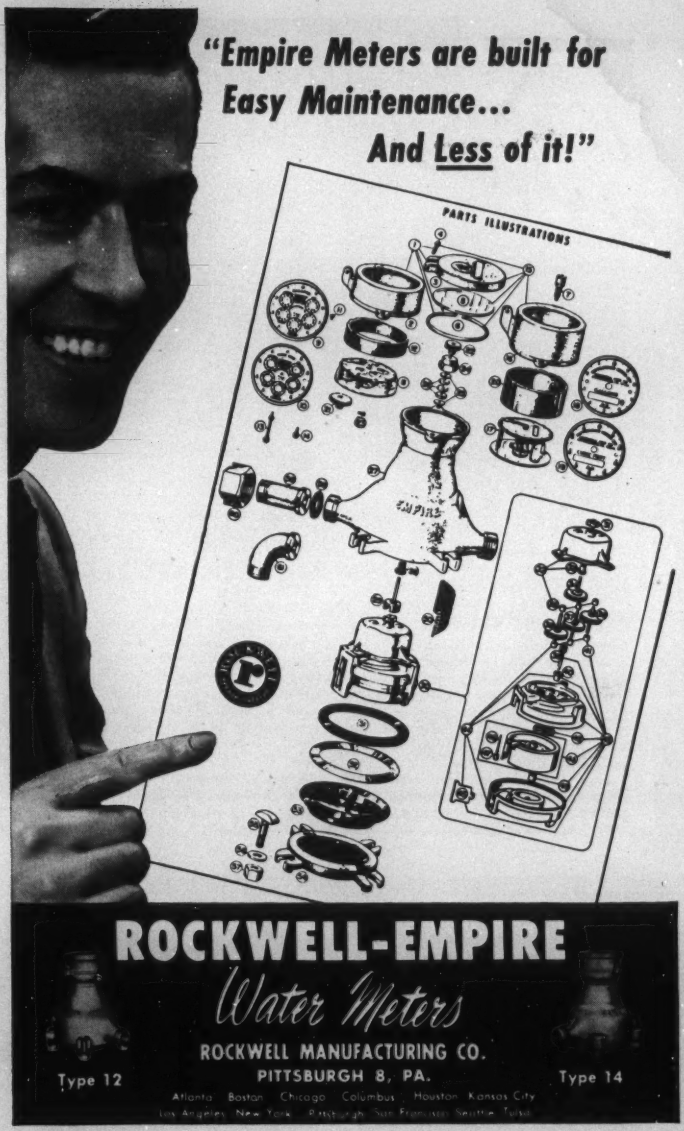
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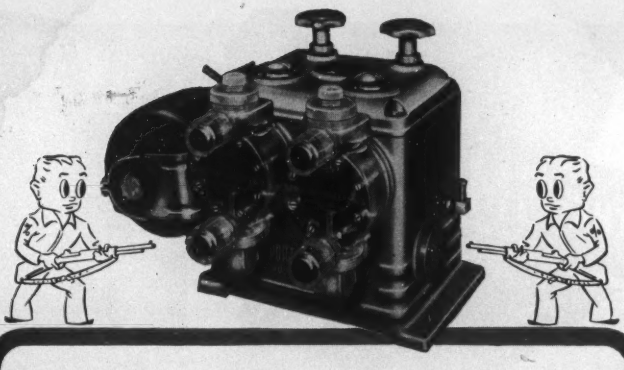

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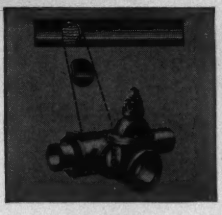

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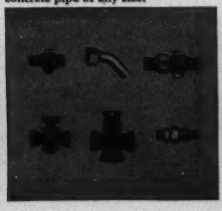

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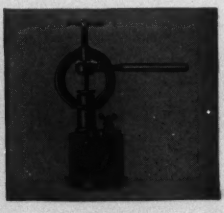

Corporation Tapping Machines. With the SMITH Tapping Machines corporation cocks can be installed under pressure. The machine is compact and easy to operate.

* Water works material of proven quality

13

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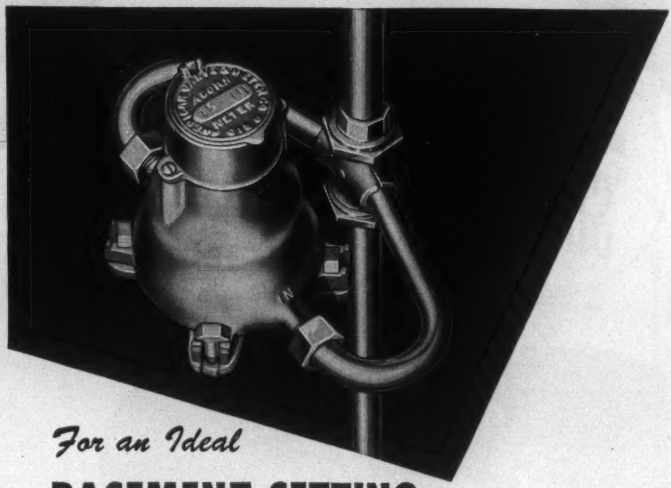

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The Ford Copperhorn provides a permanent, solidly lined-up setting for basement meters installed on vertical pipe lines. Even when meters are changed, the piping remains connected.

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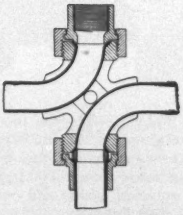

Note the smooth all-copper waterways that reduce friction to a minimum. Connections optional for either copper or iron pipe.

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● The 36-inch steel pipe pictured here is part of a new water line being laid for a well-known midwest water works. This new pipe line is about 6,000 feet in length and is protected, inside and out, by Bitumastic® 70-B Enamel.

Inside the pipe, a glass-smooth lining of Bitumastic 70-B Enamel prevents rust, corrosion and tuberculation. This spun lining of durable enamel will *keep* flow capacity high, thus reducing pumping costs. And, with this kind of protection, there's no need to spend money for *oversized* pipe in order to allow for future "shrinkage."

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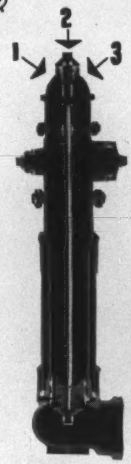

3-purpose part. Ingenious design is a feature of Mathews Hydrants—for example, use of a shield operating nut of high tensile iron. This serves three purposes.

1. It protects the soft bronze revolving nut from wrench wear.
2. It is cheaper to replace in case of damage by pipe wrenches or other improperly fitting tools.
3. It prevents dust, snow, rain or sleet from getting in around the revolving nut, always assuring free and quick operation.

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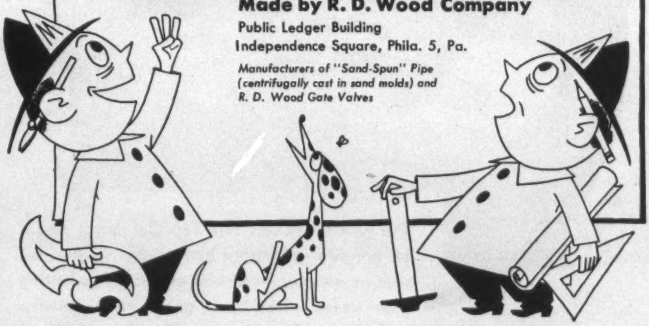

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All working parts contained in quickly replaceable barrel • Stuffing box cast integral with nozzle section —positively leakproof • Head turns 360° • Replaceable head • Nozzle sections easily changed • Nozzle levels raised or lowered without excavating • Protection case of "Sand-Spun" cast iron for extra strength, toughness, elasticity • A modern barrel makes an old Mathews good as new

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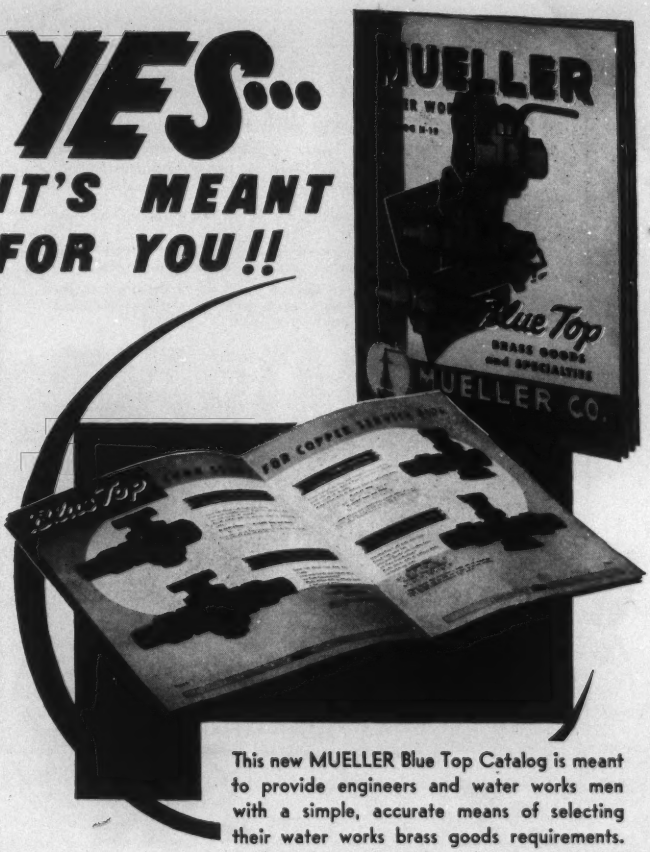

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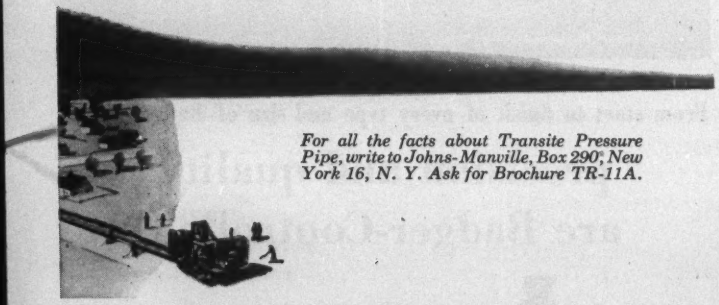
These *initial* savings . . . plus the *long-term* economies effected in thousands of installations . . . are two good reasons why you should have the complete story about this modern asbestos-cement pipe.



For all the facts about Transite Pressure Pipe, write to Johns-Manville, Box 290, New York 16, N. Y. Ask for Brochure TR-11A.

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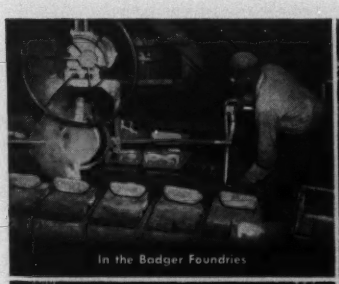
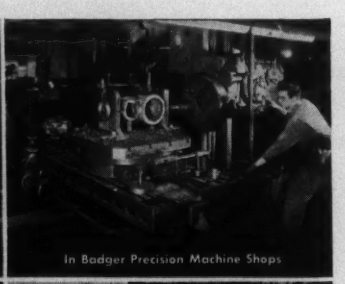

In the Badger Foundries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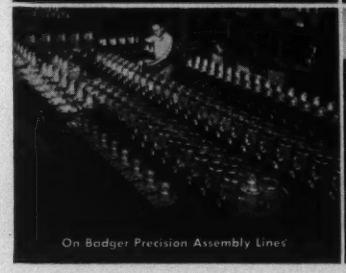
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Table of Contents

	PAGE
The Proposed New England Steel Mill By Ray M. Hudson	103
Use of Mechanical Equipment in Laying Pipe By J. G. Carns, Jr.	110
Functions, Duties and Authorities of the Public Health Service on Water Pollution Control By Leonard W. Trager	119
The Schwarzenbach Method for Determination of Hardness By J. Carrell Morris	128
The New Water Supply of Bristol, New Hampshire By Howard E. Bailey	134
Ground-Water Supply for New Britain, Connecticut By George W. Wood	143
Water Meters By James A. Sweeney	159
How Good Is New England as a Location for Manufacturing? By Arthur A. Bright, Jr.	163
Wickham Hill Storage Reservoirs By William Dorenbaum	173
Depth Determinations from Seismic Data By Robert L. Geyer	185
Book Reviews	195
Proceedings:	
January 1951 Meeting	197
February 1951 Meeting	198
March 1951 Meeting	198

New England Water Works Association
ORGANIZED 1882

VOL. LXV JUNE, 1951 No. 2

This Association, as a body, is not responsible for the statements or opinions of any of its members

THE PROPOSED NEW ENGLAND STEEL MILL

BY RAY M. HUDSON*

[*Presented December 15, 1949.*]

NEW ENGLAND needs a steel mill. There is opportunity here for one, and we have every reason to expect and believe that one will be built here and put in operation within the next three to five years. That may seem a rather long time and yet in the general run of things it is not too long. A steel mill is a gigantic thing. In the first instance, it involves the outlay of around $200,000,000 as an estimated average cost for the type of mill that we propose be built here. It takes a considerable plot of ground roughly, 2,000 acres, and a lot of other things besides.

Let me give you a few interesting facts and figures about New England's need for steel. The normal consumption of steel in New England by the metal-working industries is around 2,000,000 tons. These are the fastest-growing industries in this region. Time was when textile production was our largest industry, employing some 27% of the total workers engaged in manufacturing in New England. Today, according to the U. S. Census Bureau, textiles employ about 21%, whereas the steel-consuming and other metal-working industries, including the non-ferrous industries of the Naugatuck Valley, collectively employ about 36% of our factory workers.

There has been a very substantial growth in metal working since 1939. World War II gave a great impetus to metal working in this region, but even before the war, our industries were suffering from chronic shortages and difficulties in getting steel. There are markets which are easier for the established steel producers to reach than the New England market. In times when they had plenty of steel and didn't know what to do with it, the producers were glad to sell it in

*Secretary, New England Iron and Steel Supply Committee, New England Council, Statler Bldg., Boston 16, Mass.

New England, but when the demand was heavy, as many of our own New England factory purchasing agents will tell you, they found it rather difficult to ship into New England as much steel as was needed here.

If we take into account the pre-war needs, the expansion of industry and the post-war situation, the outlook is that we are going to need not 2,000,000 tons of steel brought in for our own industries but, over the next decade, nearer 3,000,000 tons.

In addition to that local need, we have an opportunity, if a mill is built in New England, to engage in foreign trade, being a little nearer to some of the foreign markets for finished steel than are some of our mid-West brethren.

Since the United States Supreme Court outlawed the delivered-price system of selling steel and the mills have switched over to the "f.o.b. mill" net basis, we can supply from a New England mill a substantial part of the New York City market and a part of the New York State market, penetrating perhaps as far west as Syracuse, before freight costs equalize on steel coming from either Pittsburgh or Youngstown. Taking all things into consideration, we have a potential for steel production in this region of some 6,500,000 to 7,000,000 tons.

The mill that we propose be built is an integrated mill. It will take raw ore in at one end and deliver the finished product at the other, in the form of tin plate, sheet, and hot and cold rolled strip. We have in New England some steel producers, who make specialties of various kinds. The greatest tonnage produced in New England at present runs about 400,000 to 500,000 tons annually. Thus there is plenty of opportunity for a new mill of the integrated type, and possibly for a mill or two of a specialty nature, in this region without interfering with the production of the mills already here.

The question as to where we shall get other supplies which will be necessary is important. As you know, it takes about five different things to make steel, iron ore being the most important. Scrap iron is used, too. Limestone is needed, and a lot of air and a lot of water.

Let me say a few things first about ore. I have here two maps. It won't be necessary for you to strain your eyes to look at the map in detail, because you will not be interested in the detail; all I shall want you to get is the mass effect of the map. This is a map of all

the steel mills in the United States. You will see that up in the northeast corner, where we are, there are very few dots and those few are relatively small, compared to Sparrows Point, Md., to Bethlehem, Pa., and to Birmingham, Ala. You will see also the new steel plant at Geneva, Utah, and the Kaiser plant at Fontana, Cal.

Here is a chart which shows the present ore flow in the United States. Here is the Mesabi Range, west of Lake Superior, in Minnesota. The bulk of the ore comes from Mesabi mines down through the Great Lakes, to Gary, Ind.; some comes down past Detroit into Toledo, and some goes to Youngstown via Cleveland, as well as to Pittsburgh. Quite a bit comes in from Sweden.

Here is the development which was revived during the war by the Republic Steel Corp., up in the Adirondacks. They send some ore down here into different mills that require that type of ore.

It has been variously estimated that Mesabi ore will be all gone in the next ten to twelve years. That is the richer ore, which runs about 52% iron content. There is another, less valuable ore, taconite, which can be reduced. This yields a substantial amount of iron, but costs of reducing it run high and the yield per ton of ore is not too great. The Mesabi range can supply unlimited quantities of this type of ore. However, like everything else that runs into the law of diminishing returns,—there is a question of how long it will pay to use this type of ore.

In the meantime, in Quebec, and particularly in the northwestern part of Labrador, they have uncovered deposits, easily worked from the surface, which in richness exceed the Mesabi Range at its best. These ores run from 54 to 62% iron, with some 7 or 8% manganese in them. This is another element that is important in steel making. A railroad is being built which will run 360 miles from the Ungava Bay district down to the Gulf of St. Lawrence. Ore can be hauled over it in specially-built hopper cars, adapted for mechanical loading, downgrade all the way from the mine to the St. Lawrence River, and then hauled by ships to almost any point on the New England coast for a comparatively low cost. While that same ore will be accessible to the people located along the Great Lakes, the costs of getting it up the St. Lawrence, across Lake Ontario and through the Welland Canal will be all out of proportion. There are many problems

involved, including ice in winter on the lakes, as against the relatively free and clear passage to some New England port.

It has been figured that we can get our ore quite cheaply. It is not impossible to haul ore long distances. Last year, when I was coming down the Saguenay from the Lake St. John region we passed ore boats, coming in from British Guiana, loaded with bauxite for the Aluminum Co. of Canada's plant at Arvida, Quebec. We can get ore by means of a combination of rail-and-water haul from Labrador. We can also get it from Sydney, Nova Scotia, from Sweden, Spanish Morocco or Liberia, and also from Brazil. The only question is that of the cost of the haulage. However, with the open ocean to use, we shall not be limited to special-purpose carriers, such as are used on the Great Lakes.

With regard to limestone: there is plenty of that in the hills of New England—relatively unlimited supplies. Coal would come from tidewater—that is, Hampton Roads. Presumably it would come mostly from West Virginia, by rail haul to Newport News or Norfolk and then by water haulage up here. A lot of coal comes into New England over that very route now.

The one remaining item of great significance is water. It has been said that it would require around 60,000 gallons of water per ton of steel. That is a little on the high side. From data on the subject recently given me by the American Iron and Steel Institute, a consumption of 35,000 gal., per ton is considered average in the more efficient mills; and in some specialty mills, they get along with about 17,000 to 20,000 gal., per ton of finished steel.

We figure that the mill ought to be located along the New England seacoast, particularly at a point where a 35-foot channel is possible, in order to permit the use of the latest type of ocean carrying vessel, the most modern of ore-handling equipment for discharging, and reloading into cars if necessary. But the right spot must be found so that the discharge can be made directly from the ship to the ore pile. Then by using modern mechanical conveyors and the like, a rail haul will be unnecessary. Those are things which are being thought of, too.

With regard to water, it does not necessarily have to be potable. It should be reasonably free from certain impurities. At least, it should

not be salt. Bethlehem Steel, down at Sparrows Point, is using some treated Baltimore sewage, I believe, in some parts of its plant. Of course there is a variety of uses for water around a steel mill. They want it for quenching the coke; they want it for cooling the rolls; they want it on the sheets, as they go through the rolls, for the purpose of breaking up the scale. Besides all the other things, water is used by the steel companies for sanitation, for fire protection, and so on. Thus it is easy to understand why you can run up into heavy consumption. Much depends, of course, on the size of the mill and its daily output.

Some salt water can be used for cooling purposes. This is just as logical as it is for a ship at sea to run salt water through its condensers for cooling purposes. A good, steady supply of water is most essential.

There are comparatively few places that seem to have, at the present time, the necessary water supply and logically enough, they would be those places which are adjacent to, or not too far from, some of our larger rivers. Consequently, to date a great deal of interest has been developed in the possible location of the mill, suggestions running all the way from Quoddy down through to the New York State line on the Connecticut coast. However, those spots which have been talked about the most include Kittery, Me., across the river from Portsmouth; New Hampshire believes it has a better site on its side of the river. Those of you who live around Boston have seen articles in the papers about the possibilities for a mill around Massachusetts Bay, all the way from Saugus on the North Shore around to Hingham on the South Shore. So far, according to the newspapers, Hingham is the only town that has indicated opposition to the steel mill; all the rest of them seem to be wanting it. Governor Dever states that his crew has located a site near Fall River, in Freetown.

Rhode Island has a couple of possible sites. In Connecticut, there is the New London site. There is apparently no lack of feasible sites among which we probably shall find two or three that are suitable and probably, in the last analysis, one of them will be better than the others.

The Iron and Steel Committee of the New England Council is carrying on negotiations with the steel companies. We have inter-

viewed a number of them and had dealings with the high officers. We have seen a change of attitude from one of apathy and indifference to downright interest. Whether that interest has been occasioned by the trend of legislation I do not know. I refer, of course, to the decision of the Supreme Court, outlawing the basing-point system of pricing. You will remember that legislation was introduced into the last session of Congress, designed to harmonize the differences in the House and the Senate. While it looks as though they were going to let the steel companies absorb some freight, there is no assurance that there will ever be a return to the former system of delivered prices. That being true and the steel industry being aware of that situation, it makes them think twice about decentralizing their operations, and I think we have them pretty well convinced of the richness, accessibility, and prospects of the New England market for steel. We now have some very interesting negotiations going on with some of the major companies as to how much business could be done here and what it would take to build a mill here.

That brings up the next subject—money. Apparently it will require a heavy investment from New England. There is no steel company that has at the moment $200,000,000 in its pocket which is willing to put into a new mill. Some of them point out that they might put in a substantial amount—maybe anywhere from a third up to a half of it—provided those who are interested in the mill in New England will do their part. There has been evidence of some interest in the formation of what is called a Steel Mill Authority—comparable in form or set-up with the New York Port Authority, which, as many of you know, is permitted to issue its own bonds and sell them to the public—and the use of the credit of the State behind this proposed Authority, to help finance the project. I shall not attempt to bore you with figures on the ultimate return or the "payoff," but it looks as though the property could be financed in that way and the bonds paid off in a period of 20 to 30 years. The problem is one of getting the right kind of financing behind the project and we have some evidence of interest in that. It seems to us that we have all the elements needed to bring about a positive, definite commitment on the part of some major steel interest to say, "Yes, we shall build the mill in New England." When they do that, we shall put them in touch with

the people behind the different sites and also turn over to them a great deal of information, which we have collected on both sites and markets.

The present Steel Committee is loose-knit as most Committees are, with no specific authorization to make final and binding arrangements. We are now at work on the formation of a New England Steel Development Corporation. Former Governor Joseph B. Ely of Massachusetts is our corporation counsel and he is drawing up the articles of incorporation. That has already been announced, but the actual formation of the corporation, with its officers and directors, and so on, will come a little later. That corporation will have the authority to make the final arrangements with the steel company that is to build the mill.

That tells the story in a somewhat general way I can't give you the names of any of the steel companies with whom we are negotiating. Obviously the New England Council, which is an all-New England organization, can't express a preference for a particular site.*

Let me just point out one thing more: The steel mill itself will probably employ 5,000 to 6,000 people. But if history should repeat itself here, as it did at Sparrows Point, Md., after Bethlehem built the big mill down there, we should expect to see, following the completion of the mill, an expansion of the established metal-working industries, as well as the establishment of a number of brand new specialty mills, either processing the steel further or making products from steel. Therefore we stand to gain some 30,000 to perhaps 45,000 more new jobs in New England, as and when this steel mill is really rolling in full production.

*Construction of a $250,000,000 integrated steel mill in the New London—Waterford area of Connecticut was certified on January 12, 1951, by the federal government as a defense necessity and the building of the plant was expected to get under way in the next few months.

USE OF MECHANICAL EQUIPMENT IN LAYING PIPE

BY J. G. CARNS, JR.*

[*Read January 19, 1950.*]

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BEFORE discussing mechanical equipment for laying pipe, I feel it necessary to point out some of the factors which affect, first, a decision to use such equipment and, secondly, the type of equipment to select. Of most importance in determining whether mechanical aids should be used is, of course, the necessity of determining whether their use is economically justified. In most instances this factor is rather self-evident. There have been, however, cases where equipment has been purchased that saved money on individual jobs as expected, but it was also found that aggregate savings sufficient to offset the cost of operation, maintenance and investment were not realized, because there was not enough work. A striking example of the importance of this factor is the high mortality rate of general contractors during periods when sufficient work is not available to keep their equipment busy. No clear-cut line of demarcation can be drawn to say that mechanical equipment should or should not be utilized. One method of operation may be entirely proper for one water department, but not suited for another. In general, although the primary function of all water utilities is the same, no two operate in exactly the same manner, and local characteristics dictate changes in organizational set-up and methods of doing work.

I realize, of course, that the high cost of labor in recent years has created a situation demanding review of all existing practices and has made possible the use of mechanical equipment which heretofore has not been economically justified. In arriving at a decision whether mechanical aids should be obtained at this time, consideration must be given to the fact that the peak in home construction has been passed. Past records of quantity of work performed are not a reliable guide for savings which may be realized from purchase of equipment now. Although I have tried to limit my remarks to the announced subject,

the use of many pieces of mechanized equipment is not confined to one operation. Where equipment may be used for more than one operation, such other uses will be pointed out, whether in connection with main-laying procedure or not, as total use must be the criterion of value. So much, then, for the economic aspect.

Let us look into the actual work operations involved in pipe laying and review briefly mechanical equipment suited for these operations. The broad aspects of laying pipe lines are independent of location, size of pipe, kind of pipe, or length of extension involved. For example, it is necessary to haul the pipe, fittings, valves, hydrants, tools and other material to the job site. Street paving may have to be removed. The necessary trench must be excavated. The pipe and appurtenances must be moved, lowered into place in the trench and assembled, and the trench filled in. All of these steps are necessary, whether it be a 6-inch or 60-inch pipe line of 10 ft or 10,000 ft in length.

Excavating

Of these work operations the most difficult, time-consuming and costly, of course, is making the required excavation for the pipe line. Paving removal in certain instances is also very difficult and costly, particularly if reinforced-concrete roads are involved.

Two general and distinct types of mechanical equipment are available for trenching operations. One is the power excavator of the boom-and-single-bucket type. Machines of this type are adaptable for all kinds of excavating work and also can be used as cranes for hoisting operations. Bucket attachments consist of shovel, trench hoe, clam shell and drag line, the trench hoe being most adaptable and widely used for trenching operations.

Standard bucket capacities of ⅜, ½ and ¾ cu yd, with widths varying from 15 in. to 42 in., can be obtained. Maximum trench depths of 14 ft or more are possible, depending on the length of the boom selected. Practically all makes of excavators are crawler-mounted and require trailers for hauling between jobs. Rubber-tired wheel-mounted units are available, but the cost is considerably higher than for the crawler-mounted type. Recent quotations for crawler-mounted

excavators, equipped with trench hoe attachment and powered by gasoline engines, show the following price ranges:

⅜ yard	$ 7,500-$10,000
½ yard	10,000- 13,000
¾ yard	13,000- 21,000

Diesel-engine units are slightly higher in price.

Trailers suitable for transporting these units range in price from $2,000 to $4,000 extra.

Boulders will slow down a trench hoe but not stop it. Solid rock excavation is not possible with this or any other type of trenching equipment, and special consideration in estimating cost must be given where rock is likely to be encountered.

The second type of mechanical trenching equipment consists of machines specifically designed for trench work. These units are also usually crawler-mounted and are known as wheel- or boom-type ditchers. Digging operation is continuous with these machines. The wheel type consists primarily of a large wheel, with small buckets mounted on the rim and supported by a frame arrangement, which permits rotation, raising and lowering of the digging wheel. The boom-type ditcher operates on a continuous revolving-chain principle and digging is effected by cutting teeth or buckets, closely spaced on the chain linkage. These units are available for trench widths of 5 in. to 84 in., and for depths of more than 20 ft. The cost for units of comparable trench sizes is about the same as for power excavators. Units of the continuous-chain type are available for very narrow trenches, such as 5 in., 7 in., 10 in. and 12 in. These smaller units are principally designed for service-installation and cable work. Prices range from $4,000 to $8,000 for wheel-mounted type with road speeds of 15 miles per hour or more. Under certain soil conditions either type of trencher may be most desirable. Where tough going is most frequently encountered, the tendency appears to be to favor the trench-hoe type.

It can readily be seen from the cost of units suitable for main work that this discussion is largely academic to many operators, purchase of such equipment being beyond the economic reach of most small water companies or departments. In such instances, it usually

is best to have a general contractor, experienced in pipe laying, do the work. If I have been able to anticipate correctly that which is foremost in your minds in this phase of mechanical aids in laying pipe (and I don't claim to be psychic), what you want and need most is a highly mobile trenching unit, capable of moving under its own power on its own rubber-tired wheels at reasonable road speeds from small job to small job and, once there, doing an effective job of excavating under most soil conditions the necessary trench for laying 6-inch or 8-inch pipe. Of course, this unit must be reasonable in price and preferably capable of lifting heavy pipe, hydrants and fittings. If this trencher can also do any other of the necessary operations, such as backfilling, pavement breaking or tamping, so much the better. That's a pretty big order and one that I have been trying to fill for some time. There is recognition of the need for a small mobile trencher and the use of hydraulic or air pressure for power to operate the trenching mechanism appears to hold promise of our being able to obtain such equipment in the near future.

I have recently witnessed a demonstration of a hydraulically operated trench hoe of ⅜-yd capacity, mounted on a rubber-tired tractor, which does a very effective job of trenching and sells for approximately $6,800. This unit weighs about 10,000 lb and has a road speed of 20 m.p.h. Six-inch or 8-inch pipe in 18-foot lengths is readily loaded on trucks, removed and lowered into the trench with it. An attachment of completely new design for backfilling is also to be available. The backfilling attachment is an extra, and the complete unit for trenching, hoisting and backfilling will cost appoximately $8,000.

One more point on trenching is that consideration should be given to the width of trench excavated for various pipe sizes. Usually, the width of trench is dictated by available equipment. Bucket sizes are more or less standardized, although they can be obtained to suit your specifications. Generally, the boom- or wheel-type ditchers have a limited range of widths for a given size of machine. Extra width above that necessary to install the pipe, of course, slows down the speed of trenching. Where paving is involved, the extra width also imposes extra paving costs which, in this day and age, are considerable.

It does not appear reasonable to cut a wide trench the entire

length of an extension, when extra width over that of the pipe size is required only at the bell-hole locations. A trench hoe with 12-in. bucket width can, by making a few extra passes, enlarge the trench width for bell holes as needed and do more work than one which cuts a continuous trench, 20 in. or more in width. The narrow bucket is not too effective under wet, sticky soil conditions, as difficulty is encountered with the excavated material's adhering to the bucket. Under such conditions, a bucket with a width of 15 in. or more is needed. This condition does not usually occur frequently enough to warrant purchasing only the wider bucket and using it on all jobs.

As an example of what can be done along this line, we have installed 6-in. cement-asbestos pipe in a trench, 4 ft 6 in. in depth and 10 in. in width, which was dug by a "Jeep-a-Trench" outfit. This is one of the small, so-called service trenchers, which sells for about $4,000. The pipe was assembled on short 2″ × 4″ stringers across the ditch and progressively lowered into position by rope slings. With suitable hoisting equipment the same thing could be done with two 18-ft lengths of 6-in. cast-iron pipe, which would reduce by half the number of bell holes required. About 80% of the extra trench width at bell-hole locations in this case could be done by the Jeep, making a second 10-in. cut and leaving a narrow bridge wall between for hand excavation.

So far, I have been discussing equipment for normal trenching operations. We also make use of another unit to reduce hand labor. This is an air-operated clay spade, powered by a small, portable air compressor of either 20- or 30-cfm capacity. The air spade loosens clay and hard ground formations, including frozen ground, faster and with much less physical effort than by using a pick. These clay spades are used principally in maintenance and service-installation work. Even where trenching machines are used in extension work, there is a certain amount of work for these small units. The compressor units are either portable or trailer-mounted and weigh from 350 to 1,000 lb. The two-wheel trailer-mounted ones which we favor have tool-storage space and are easily towed by car or truck at ordinary road speeds. The cost complete for the 30-cfm size with electric starter, air hammer, clay spade, tamper pads and moil points is approximately $1,200.00. Of course, where larger sizes of compressors are available, these units

are used to provide air for the clay spade. We find, however, that the larger compressors are usually tied up on heavier work and the small units are valuable for work usually performed by hand, because other equipment is not available.

Excavating for small piping, such as in service work, may be materially reduced by using any of a number of pipe-pushing machines. In certain of our larger companies we use an air-operated drifter drill for this purpose for ¾-in. and 1-in. service pipe. The drifter drill eliminates difficulty experienced with pipe-pushing machines which will not hold line and grade, where difficult ground formations are encountered. The drifter drill will drill a hole through solid rock and in soft soil acts the same as a pipe-pushing machine. Large-capacity pipe-pushing or earth-boring machines are also frequently used to install large-diameter pipe under paved roads and railroad tracks, where soil conditions are favorable for this operation.

Hoisting Equipment

Hoisting equipment for handling pipe, hydrants and heavy fittings usually consists of some form of frame of sufficient height, which is attached to the body of a truck and on which is mounted a winch or chain hoist. Mechanization of this operation consists of the winch's being powered by the truck engine through a power-takeoff connection or power wrench. We have also equipped some of our trucks with small hydraulic cranes. These units are very handy and easy to operate. Lifting is done by pumping a small handle by hand, which actuates the hydraulic piston, which in turn raises the crane arm. Lowering is accomplished by releasing the hydraulic pressure through a small needle valve. The units which we use have one-ton capacity, although larger sizes are available. One advantage of this type of unit is that it is low in height and can be left fully mounted on the truck body. Most types of lifting equipment, mounted on trucks, usually require dismantling to allow the truck to be driven along the road or through garage doors of ordinary height. To offset this advantage of the hydraulic hoists, they have the disadvantage of having only a limited lifting range, making it necessary to lower material from the truck body to the trench in two stages. Pipe is usually lowered to the ground and a longer sling used to lower it the rest of the way. This is not a

serious disadvantage. Where the backhoe-type of trenching equipment is used to excavate the trench, a chain or rope sling is usually suspended from the bucket for hoisting operations. Where large quantities of material must be handled, as is the case with extensions of great length, it is often found desirable to utilize a separate power-crane unit for lifting, so as not to impede the progress of the trench hoe in its primary job of digging.

The power wrench mentioned is operated either by an air motor or electric drill of ½-in., ⅝-in. or ¾-in. size. This wrench consists of a set of reduction gears of 30:1 ratio, encased in an aluminum housing with handle about 3 ft long. The air motor or electric drill is fastened to the handle and power furnished by an air compressor or generator set. The entire wrench set weighs only about 60-70 lb and does any job of turning operations which can be done by hand. We use them to operate winches for lifting operations, valve turning, and mechanizing large-size tapping machines and pipe-threading machines. Other uses for this equipment in your own plant will probably be evident. Cost of power wrench only is $200. A ¾-in. electric drill is about $75.00 additional.

Backfilling and Tamping

Backfilling, of course, is best accomplished by using a tractor-mounted bulldozer, particularly when large quantities of material must be handled. This work is also done by using a power excavator with shovel bucket or an ordinary snow-plow blade, mounted on the front end of a truck. If the truck is equipped with a winch, powered by a takeoff connection, this unit can also be used for backfilling operations, in which case a large scraper or hand-held scoop shovel is employed.

The new type of backfill arrangement, which I mentioned but did not describe in connection with the hydraulically operated trench hoe, is to be a side-mounted blade, actuated by telescopic hydraulic rams. Experimental models have proven successful. It is not possible at this time to say whether one run parallel with the trench will enable complete cleanup of the spoil or additional passes will be necessary. This, of course, will depend on the base width of the excavated material and quantities involved. The advantage of side-mounted blade

is, of course, evident. Any arrangement which eliminates the necessity of jockeying back and forth will speed up this operation and be a decided improvement.

Mechanical tamping of backfill almost universally involves the use of air-operated tampers. These tampers may be of the independent type or involve using a paving breaker with a tamper pad. The small air tampers are light in weight and less burdensome to the person operating them. A paving breaker with tamper pad is quite heavy and quickly tires the person operating it. I observed a demonstration about one year ago of a completely different type of tamper which, at that time, was manufactured in England and known as a Johnson Rammer. Apparently American rights for this tamper have since been issued, as an American model of a portable, self-contained gasoline-operated rammer is now available. This unit is claimed to have the ability to replace to 95% compaction 18-inch layers of sand or gravel and 9-inch layers of clay. The tamper operates at about 60 blows per minute, as compared with the much speedier air-operated tampers. It has, however, a much larger tamping-pad area (10-in. diameter) and is stated to be able to do the work equivalent to four or five pneumatic tampers or two to three pneumatic paving breakers with tamper pads. Since it is a self-contained unit, the cost of approximately $600 is attractive, as compared with that of a 105-cfm compressor and tools of approximately $3,000-$3,500. Of course, this is not a true comparison of relative cost, as the air compressor can be used for other operations, whereas the self-contained gasoline units are designed only for tamping.

Pavement Breaking

Depending on quantity and type of paving to be broken, the following machines are employed, all of which are air-operated. For large sections of concrete paving, there is available a very large unit, consisting of a vertical air cylinder and piston, mounted on the rear of a truck, carrying a 210-cfm air compressor. Heavy demolition points and tools are attached to the lower end of the piston rod. A smaller unit of the same general principle is a wheel-mounted job, which operates from a separate 105-cfm compressor. This smaller unit also has wide chisel points and is sometimes used in scoring and

removing macadam paving. Either of these units may also be used for backfill tamping.

You, of course, are all familiar with air-operated paving breakers, the usual method for doing this work. There is a new type of electric paving breaker, which has certain advantages over those of air operation. This unit is powered by a small gasoline-engine-driven generator and, in a test demonstration which I witnessed, did an equivalent, if not more effective, job on an 8-inch, reinforced-concrete road slab to that done by an 80-lb, air-operated paving breaker. The electric breaker operates at much slower speed than an air tool, but has more striking power. It can be classified as roughly equivalent to air-operated breakers and has the advantage of not requiring the purchase or tying-up of a large air compressor. The generator may also be utilized for emergency night lighting or to operate other high-cycle tools. The cost for generator and electric breaker is approximately $1,100. The small 20- or 30-cfm compressor and clay spade previously described, equipped with 3-inch chisel bit, is also very handy for scoring and removing macadam or penetration-type road surfaces.

Laying and Joining Pipe

There is not much to be said for mechanical tools for this phase of pipe laying, other than the use of air-operated tools for caulking lead joints. This practice, which is not usually resorted to, unless the size of pipe is large, is an operation with which I am sure you are all familiar.

It is probably evident by now, even to one not already familiar with water-works practice, that the principal aim in mechanization is to obtain equipment capable of doing as many different operations as possible—*and keep it working!* A machine may not be economically justified if its use is limited, whereas, if utilized to its fullest extent, it may be indispensable.

FUNCTIONS, DUTIES AND AUTHORITIES OF THE PUBLIC HEALTH SERVICE ON WATER POLLUTION CONTROL

BY LEONARD W. TRAGER*

[*Read January 19, 1950.*]

As THE title suggests, this paper was designed to give you an explanation of some of the things required by the Public Health Service in carrying out the provisions of Public Law 845 of the 80th Congress or, more specifically, the Water Pollution Control Act. In preparing this paper it was my thought that it should answer some of the questions many of you have put to me. I have in mind some of those questions, such as: "What are your duties?"; "What is New England's position in the Federal pattern of water pollution control?"; and, finally, "What is New England's future in so far as stream pollution corrections are concerned?"

It is not surprising to us that you should ask such questions, because this sort of sectional thinking and questioning was foreseen. In fact, the Washington authorities, while they realized there would be many problems of a regional nature, also knew that a successful water pollution control program had to be developed by dividing the country into natural drainage basin areas rather than by partitioning the country into groups of States. Fortunately, the 14 major river basins selected for current field operations in the country are so located that they not only meet the requirements imposed upon us by nature but also those imposed upon us by our sectionalism, industry and economy. Over the years, changes in our economy have been influenced only slightly by the States themselves. In contrast, our streams have influenced our economy—in fact our whole lives—more than any other one thing. Both New England's history and future are tied to either the ocean or the streams. It follows then that a logical conclusion, based on the above facts, would require a New England Drainage Basin for field operations for the Federal Government's activities in water pollution control.

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The question that is probably uppermost in your minds is: How does this program tie in with public water supplies? The answer to this question, I believe, is obvious, because water pollution control is not simply a program designed to prohibit all pollution but to control it to the extent that the receiving waters will be made to conform to the uses to which they are best suited in the reasonably foreseeable future. This water-usage fact was recognized by Congress and was, therefore, inserted in the law.

Section 2(a) of the law states that the Surgeon General shall, in coöperation with other Federal agencies, with State water pollution agencies and interstate agencies, and with municipalities and industries involved, " . . . prepare or adopt comprehensive programs for eliminating or reducing the pollution of surface and underground waters." In the development of such programs, the law states, " . . . due regard shall be given to the improvements which are necessary to conserve such waters for public water supplies, propagation of fish and aquatic life, recreational purposes, and agricultural, industrial and other legitimate uses."

As you will note, "public water supplies" leads the number of water uses listed in that provision. In other words, we are directed to give consideration and adequate study not only to the present stream usage but to the conservation of these waters for specific future uses. How our studies and comprehensive reports will emphasize the steps necessary to conserve waters for public water supply uses may be cited in the example of the proposed Hudson River auxiliary water supply project for New York City. If the city of New York is, at any future time, planning to use the Hudson River as a source of supply, this fact must be taken into consideration in our comprehensive report and, at the same time, it must be indicated how these waters can be made fit or conserved for such a high-priority project.

Time will not permit a detailed account of all duties assigned to the Public Health Service under the Water Pollution Control Act. I shall, nevertheless, explain a few of them. First, however, I believe that something should be said about the basic principle of the Act. It appears in the first sentence, as follows: "That in connection with the exercise of jurisdiction over the waterways of the Nation and in consequence of the benefits resulting to the public health and welfare

by the abatement of stream pollution, it is hereby declared to be the policy of Congress to recognize, preserve, and protect the primary responsibilities and rights of the States in controlling water pollution, to support and aid technical research to devise and perfect methods of treatment of industrial wastes which are not susceptible to known effective methods of treatment, and to provide Federal technical services to State and interstate agencies and to industries, and financial aid to State and interstate agencies and to municipalities, in the formulation and execution of their stream pollution abatement programs."

Probably the most important function of the field offices of the Division of Water Pollution Control—and the New England Drainage Basin office is one of them—is the preparation of the comprehensive reports. As stated previously, section 2(a) of Public Law 845 makes it mandatory for the Surgeon General, in coöperation with other Federal agencies, State water pollution agencies and interstate agencies, and municipalities and industries involved, to prepare or adopt comprehensive programs for stream pollution control. All activities involved in the development of comprehensive programs will be undertaken jointly with State water pollution control agencies and the interstate agencies.

The purpose of the comprehensive reports is to produce documents that will be suitable for use by the States in carrying out technically and economically sound pollution abatement programs. From the Federal point of view, these reports will be used to support State programs and will act as guides to the various types of Federal actions that are authorized by the law. These reports will also act as guides in resolving divergent views regarding water uses, treatment required, and other factors.

It is known that some States have practically no information on the conditions of their streams. On the other hand, some of the other States know a great deal, but they, too, still lack some of the fundamental data necessary to prepare a definitive comprehensive report.

In general, the final development of comprehensive reports will be preceded by preliminary reports, based on information presently available. The preliminary reports will point to gaps in data and will serve as guides for obtaining the necessary information.

By following this procedure, the States ultimately will be in a position to determine the most suitable water uses and prepare their programs accordingly. In my contacts with the State water pollution control authorities, I have been informed that they are all desirous of obtaining the type of information we are endeavoring to assemble for them.

The preparation of the baseline reports will include data to:

1. Provide a reference point to measure progress.
2. Provide a guide to needed additional information.
3. Provide a basis for the further development of comprehensive programs.
4. Determine, to the degree possible, a list of treatment works which are obviously necessary and which will be in accord with any subsequent comprehensive program.
5. Provide a basis for loan approvals.
6. Provide an educational document to aid in marshalling public opinion and providing information to officials concerned.

From the above starting points, the Public Health Service and the State water pollution authorities will begin to prepare or develop the more definitive comprehensive reports. As we see it now, this latter program will require the preparation of suitable reports, based on data adequate to allow for:

1. Determining the desirable stream uses for reasonably foreseeable future.
2. Fixing water quality requirements.
3. Determining existing stream conditions and the ability of the stream to assimilate the allowable pollution.
4. Developing necessary corrective measures, based on items 1, 2 and 3 above.

As stated previously, the comprehensive reports reflect the combined efforts of the States and the Federal Government. They may also represent the work of interstate agencies. Here in New England, then, the integrated reports may be considered as the New England Interstate Water Pollution Control Commission's report, because they will be cleared there before they are made public. In preparing the reports, it will be necessary for us to consult other Federal agencies, State agencies, and groups or persons having an interest in pollution abatement, especially those whose local knowledge increases the value of their opinion.

As this program progresses, experience may dictate that in order to assure consideration of all views and opinions, public hearings

may be necessary. Such hearings, if they are to be held, will, for the most part, be reserved for the more definitive reports.

I believe you will now agree with me that these reports are truly engineering reports in every sense of the word. Whenever a municipality, State, or the Federal Government undertakes a public utility construction program, the authorities are invariably supplied with engineering data pertaining to:

1. Existing conditions.
2. Reasons for the planned improvements.
3. The cost and other economic aspects.

Our program is designed to do the same thing on a utility or, more specifically, upon a natural resource that has, in the past, been subject to practically no planning whatsoever. As for stream sanitation, I do not want to portray the idea that the States have done nothing. That is not the case. On the other hand, I do wish to state that practically none of the States has ever developed a planned program for an entire river basin. As you may see, our job, therefore, is made clear, because we can coördinate the work of the States not only as it may apply to single interstate streams but also as it applies to the country as a whole.

The need for applying measures applicable to States, regions, and the country as a whole brings up the problem in water pollution control of how to manage a program when the economic resources, population densities, and laws vary from State to State. This is a real problem and worthy of some thought because, as you know, there is real competition among the States which are trying to obtain new industries or to retain industries already existing within the borders of the State. Naturally, we should not want to see an industry move from one State to another solely because the first State was making an honest effort to better its streams while the other was either closing its eyes or was unable to act because of inadequate laws.

On this matter, too, Congress recognized both the extent of the problem and the difficulties involved. It therefore directed the Surgeon General to encourage coöperative activities among the States for the prevention and abatement of water pollution, to encourage the enactment of uniform State laws relating to water pollution, and to

encourage compacts among States for the prevention and abatement of water pollution.

While it is generally considered impossible and even undesirable to have all State water pollution control laws precisely alike, we do believe that certain fundamental principles should be included in all State laws. One of these principles might well contain some stipulation pertaining to new sources of pollution. If this particular requirement existed in all State laws, it is probable that industry would find it difficult to move from one State to another just because they desired to dispose of their wastes in an inexpensive manner and with no regard to the rights of stream users.

Speaking of State laws, I believe it would be to your benefit to know that considerable activity in the field of State water pollution legislation has occurred in the past decade. Over half the States passed new laws or amended their old statutes within this period. Because this type of legislation has been concentrated within a relatively recent period, it is not surprising to find a marked similarity in the enactments. In general, they have followed the technique of setting up a single administrative agency to deal with the problem of water pollution.

The modern tendency is to coördinate all State water pollution control activity under a single administrative agency, charged with the responsibility of enforcing State laws relating to the abatement of water pollution. In accordance with the provisions of the Water Pollution Control Act, such an agency may be recognized by the Public Health Service as the official State water pollution control agency and may participate in the benefits provided under the terms of the Act.

Many of the States which have passed legislation in recent years have set up boards or commissions, made up of members appointed by the Governor. Other States have appointed ex-officio boards, composed of heads of State departments having related responsibilities, such as health, conservation, agriculture, industry, etc. These groups have been given comprehensive powers with which to develop programs for the prevention and abatement of water pollution throughout the State.

In line with desirable practice, these boards have been provided with powers to hold hearings and, when necessary, to issue orders

relating to the abatement of pollution. In addition, they have been given adequate authority to take legal action against violators of pollution abatement orders.

As to the enactment of laws in both New England and the State of New York in recent years, emphasis has been placed upon the classification principle of the control of water pollution. This type of procedure has been adopted in the aforementioned areas, because it is recognized that all waters must be placed and maintained in a condition best suited to the needs and uses of the people concerned.

Section 2(d) of Public Law 845 of the 80th Congress contains a regulatory provision, declaring that pollution which arises in one State and endangers the health or welfare of people in another State is a public nuisance. This section also provides for public hearings and for court action.

To me, the most significant part of the regulatory features of the law is that which provides for the holding of hearings, during which facts on a particular case can be brought before the public. Whether the offender is a municipality or an industry, we believe that public opinion will aid greatly in bringing about a satisfactory solution. I should like to state at this point that the Public Health Service is ready to assist industry in working out ways and means of treating industrial wastes. However, primary responsibility for developing methods of treatment and for constructing treatment works lies with industry.

The law provides authorization for loans to States, interstate agencies and municipalities for the construction of treatment works to the limit of $22,500,000 annually for a 5-year period, beginning July 1, 1948, with a maximum loan of $250,000 for an individual project. Additional funds also are authorized annually, as follows:

1. $1,000,000 for grants to States and interstate agencies for investigations, research, surveys and studies, related to the prevention and control of pollution, caused by industrial wastes.
2. $1,000,000 in grants to States, municipalities, and interstate agencies for advance planning of remedial works.
3. $2,000,000 for the operation and administration of this program by the Public Health Service.
4. $500,000 for the administration of the Federal Works Agency functions under the law.

5. $800,000 for construction of a Public Health Service laboratory building at Cincinnati, Ohio, for water pollution research. (The President in his recent budget message to Congress asked for $3,800,000, to be made available July 1 for prompt construction of this facility. The requested amount, with $200,000 appropriated in 1948, would complete the $4,000,000 authorized by the Water Pollution Control Act.)

To date, total appropriations under the Act have amounted to $2,725,000. Of this amount $275,000 went to the Federal Security Agency (of which the Public Health Service is a constituent) and the General Services Administration for operational purposes during the fiscal year ending June 30, 1949. The remaining $2,450,000 was appropriated to both agencies for the current fiscal year for operations and for Public Health Service industrial waste grants.

From the money appropriated by Congress for grants to study the industrial waste problem, the following sums have been paid in this fiscal year to the New England States and the New England Interstate Water Pollution Control Commission:

Connecticut	$12,296
Maine	$10,941
Massachusetts	$18,780
New Hampshire	$10,125
Rhode Island	$10,127
Vermont	$ 9,559
New England Interstate Water Pollution Control Commission	$10,000

An additional $12,500 has been granted to the State of Massachusetts for special research on the treatment of wool-scouring wastes.

As for New England's future in so far as stream pollution corrections are concerned, I should first like to say that we need not be too ashamed of what we have done in the past. What we may look for in the future depends upon how fast the State authorities wish to proceed. On this point I can assure you that all the New England States are committed to making greater strides than they have in the past, because all of them, within the past few years, have accelerated their programs. To me, at least, the future of New England with regard to stream improvements looks bright.

Discussion

Francis X. Crowley (Boston, Mass.). Does the Public Health Service have any executive powers to force communities to install sewage-treatment plants, particularly in cases where one city is polluting the water and another city is receiving the polluted water?

Mr. Trager. Yes, the Surgeon General has that authority. The first thing, of course, is to hold public hearings and it is our belief that the mere fact that the Public Health Service—the Federal Government—is holding public hearings in a community, involving pollution coming from one city to another, will more or less force action by the municipality or by the industries involved. We do not think it will get far enough for court action. However, it can go to court action, if desired.

THE SCHWARZENBACH METHOD FOR DETERMINATION OF HARDNESS

BY J. CARRELL MORRIS*

[*Read at Chemists' Round Table, Feb. 16, 1950.*]

WATER chemists have for a long time wanted a procedure for the determination of hardness in water that would be both rapid and accurate. The various soap-titration techniques and the palmitate method are fairly rapid, but they do not yield precise results. Standard analytical methods for calcium and magnesium, while of good accuracy, are time-consuming and require skillful technique.

A method which appears to have solved the problem has now been developed as a result of the work of Schwarzenbach and his associates in Switzerland (1, 2, 3). During the past two or three years additional critical studies of the method have been carried out in this country, to explore the range of validity of the test and its accuracy, and to specify the best conditions for the conduct of the test (4, 5, 6). As a result of these investigations, it is indicated that the Schwarzenbach method is about twice as rapid as the standard soap titration and that it yields results of the same order of accuracy as the standard analytical methods—within 2 ppm on waters in the usual range of hardness.

PRINCIPLES OF THE METHOD

The chemistry of the titration is very interesting and its application to the analytical problems has been highly ingenious. Schwarzenbach found that calcium and magnesium ions would form stable complexes with the disodium salt of ethylenediaminetetraacetic acid (formula $Na_2H_2C_2H_4N_2(CH_2COO)_4$, designated as Na_2H_2T) according to the equations

$$Ca^{++} + Na_2H_2T \longrightarrow CaH_2T + 2Na^+$$
$$Mg^{++} + Na_2H_2T \longrightarrow MgH_2T + 2Na^+$$

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When a solution of disodium dihydrogen ethylenediaminetetraacetate is added to a water containing these ions, the complexes form rapidly and completely. The calcium complex is more stable than the magnesium one, so that as the solution of Na_2H_2T is added, the calcium complex forms first, and only when calcium ions have reacted essentially completely does the magnesium complex form.

Since both complexes are colorless, some sort of end-point indicator is required to make the reaction useful in an analytical procedure.

Biedermann and Schwarzenbach (3) found that the dyestuff Eriochrome black T, or F241, could be used as an indicator for the titration. This dyestuff is a tribasic acid (designated as H_3In) which gives the following reactions in water:

$$\underset{\text{wine red}}{H_2In^-} \overset{\text{pH 6.3}}{\rightleftharpoons} \underset{\text{blue}}{HIn^=} \overset{\text{pH 11.5}}{\rightleftharpoons} \underset{\text{orange}}{In^{\equiv}}$$

In solution between pH 8 and 10 the dye reacts with Mg^{++} to form a complex according to the equation

$$\underset{\text{blue}}{HIn^=} + Mg^{++} \rightleftharpoons \underset{\text{wine red}}{MgIn^-} + H^+$$

Hence, when some of the dye F241 is added to a solution containing Mg^{++} that has been buffered between pH 8 and 10, the solution takes on a wine-red color. Now, if this solution is titrated with ethylenediaminetetraacetate, the color remains unchanged until a sufficient amount of the reagent has been added to react with all of the hardness present. Then, because the MgH_2T complex is more stable than the $MgIn^-$ complex, the reagent takes the Mg^{++} from the dye complex and the color of the solution changes from red to pale blue.

Calcium ions also form a complex with the dyestuff, but it is not stable enough to serve as an indicator. Therefore, when no Mg^{++} ions are present in the water or when the reagent is being standardized against calcium carbonate, magnesium ions must be added to the solution. This is accomplished automatically by dissolving some magnesium salt in the titrating reagent before it is standardized. Then,

as the titration proceeds, Mg^{++} ions are introduced into the solution, but no extra calculations or corrections are required.

Reagents* and Procedure

(1) *Indicator.* Dissolve 0.5 g of Eriochrome black T in 100 ml of alcohol.

(2) *Buffer.* Mix 67.5 g of NH_4Cl with 570 ml of concentrated NH_4OH and dilute to 1 liter.

(3) *Standard Calcium Solution.* Prepare as in "Standard Methods for the Examination of Water and Sewage."

(4) *Standard Na_2H_2T Solution.* Weigh out 4.00 g of reagent-grade disodium dihydrogen ethylenediaminetetraacetate** and 0.100 g of $MgCl_2 . 6H_2O$. Dissolve these salts in about 750 ml of distilled water. Then titrate 25.0 ml of standard calcium solution with this reagent, according to the procedure for the determination of hardness which follows. On the basis of the standardization, dilute the Na_2H_2T solution so that 1 ml = 1 mg of hardness.

For the determination, measure with a pipette 50 ml of water sample into a 250-ml Erlenmeyer flask. Add 1 ml of the buffer solution and then 3 or 4 drops of indicator. (It is necessary to add the buffer before the indicator, to avoid interference by iron.) Titrate the sample with the standardized reagent as rapidly as desired. At the end-point the color changes from wine red to a clear pale blue with no trace of red remaining; i.e., the end-point is the complete disappearance of the red color, not the first change in hue. Calculate the hardness from the ml of reagent required.

Discussion

The precision and accuracy of this method have been extensively studied by other authors (3, 4, 5, 6). Some indication of the precision that can be obtained even by inexperienced analysts is shown in Table 1, which presents results obtained on two samples of water by students in a water-analysis course. No results from the class have been omitted.

*Reagents or solutions of them can be obtained from the Hach Chemical Co., Box 597, Ames, Iowa, and from W. H. and L. D. Betz, Philadelphia, Pa.

**This chemical is sold commercially under the trade name of Versene. There are also other trade names.

TABLE 1.—RESULTS OF STUDENT TITRATIONS FOR HARDNESS BY SCHWARZENBACH TECHNIQUE

Sample A—Cambridge tap water		Sample B—Synthetic, containing 350 ppm Ca hardness and 100 ppm Mg hardness*	
86	83	460	460
86	83	462	452
84	83	463	451
84	84	463	466
85	79	465	456
83	81	449	449
83		459	
Ave.: 83.4		Ave.: 458	

*These concentrations were determined from the weights of c.p. salts used. They may have been slightly in error because of uncertainties in composition. Therefore the difference between 450 and 458 does not represent inaccuracy in the titration.

In addition to its speed and accuracy, the method has other advantages. Samples containing up to 1,000 ppm hardness, or even more, may be titrated without dilution. However, if large amounts of Mg hardness are present (> 200 ppm), it is advisable to dilute the sample, to avoid precipitation of $Mg(OH)_2$. By using a more dilute reagent, results within 0.1-0.2 ppm can be obtained on waters with less than 2 ppm hardness (6). The titration is unaffected even by large concentrations of NaCl. Consequently, the method can be used in checking the regeneration of ion-exchange resins and possibly even for titrating hardness in sea water.

INTERFERENCES

Probably no analytical method is entirely free from interference by ions or compounds other than those one wishes to determine. The ions likely to be found in water that interfere most seriously with the Schwarzenbach titration are those of copper and manganese. (Nickel and cobalt ions also interfere, but are not commonly found in water supplies.) However, relatively simple modifications in the procedure have been developed to take care of the interfering ions, so that their presence need cause no concern.

Normally, in the presence of copper ions greater than 0.1 ppm a satisfactory end-point to the titration is not obtained, apparently be-

cause copper forms a red complex with the indicator that is not decomposed by the titrating reagent. Connors (4) and Diehl, Goetz and Hach (5) found that by adding sodium diethyldithiocarbamate to the solution, the interference of up to 5 ppm of copper was eliminated. The diethyldithiocarbamate can be mixed with the indicator solution (4.5 g per 100 ml). Then when the indicator is added, copper interference is automatically excluded.

Manganese appears to catalyze the decomposition of the indicator, causing indistinct end-points. This interference for concentrations up to 20 ppm of Mn can be eliminated by adding hydroxylamine hydrochloride to the solution. Again, the reagent can be mixed with the indicator (4.5 g per 100 ml).

If very large amounts of copper or manganese ions are present or if the solution contains cobalt or nickel ions, sodium cyanide (0.25 g) may be added, to overcome their interfering effects. The use of the cyanide, although it is effective against virtually all of the metallic-ion interferences, is recommended only when the other modifications are not satisfactory, because of the poisonous nature of cyanides.

Betz and Noll (6) propose the use of a borax buffer, containing sodium sulfide, in place of the NH_4OH-NH_4Cl solution and claim that when this buffer is used, there is no interference by copper, manganese, or many other metals. However, Diehl, Goetz and Hach (5) find the borate-sulfide buffer unsatisfactory.

Sequestering agents like the polyphosphates are also a potential source of difficulties in the titration. Experimentally there is some disagreement as to their effect. Diehl, Goetz and Hach (5) state that the method is not satisfactory in the presence of polyphosphates, whereas Betz and Noll (6) find that concentrations up to 25 ppm can be tolerated without error.

Separate Calcium and Magnesium Determinations

The standard Schwarzenbach titration does not yield values for the individual calcium and magnesium concentrations in the solution. Magnesium can be determined by first precipitating and separating the calcium as oxalate. It also appears possible to determine calcium separately by using a different indicator for the titration (4, 6).

As the latter technique is still in the experimental stage, its reliability is not certain.

Summary

Hardness in water can be rapidly and accurately determined by titration with a solution of disodium dihydrogen ethylenediaminetetraacetate, which forms stable complexes with calcium and magnesium ions. In the pH range 8 to 10, the dye Eriochrome black T, used as an indicator, shows a sharp color change from red to blue at the end-point of the titration. The method is precise to 2 ppm or better, takes about half the time required for a soap titration, and is directly applicable over wide ranges of hardness. It is not adversely affected by high concentrations of many types of dissolved salts. The temperature of the solution has little effect. There are only a few substances which interfere and the disturbance they cause can be eliminated by simple modifications in the standard procedure.

Although further field experience is needed before the method is adopted as standard, it appears likely that this Schwarzenbach titration is destined in the near future to replace the soap method for the determination of total hardness in water.

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THE NEW WATER SUPPLY OF BRISTOL, NEW HAMPSHIRE

BY HOWARD E. BAILEY*

[*Read February 16, 1950.*]

THE Bristol Aqueduct Co. was organized in 1886 to furnish water from Newfound Lake to the town of Bristol (see Fig. 1) with $20,000 capital stock, consisting of 400 shares of $50.00 each.

Original System

The backbone of the system includes an intake in Newfound Lake, constructed of 21-in., galvanized, corrugated iron pipe, which in turn connects to about 3,000 ft. of wood-stave pipe. Within the limits of the village a 10-in. cement-lined steel pipe was laid to the center, with 6-in. and 4-in. branch lines in the neighboring streets.

The corrugated, steel intake pipe, which lies on the bottom of the lake, was replaced a few years ago. The wood-stave pipe, although reported to be in excellent condition, has developed numerous small leaks, which decrease the fire flow downtown. The cement-lined steel pipe is fragile, and care must be exercised in operating the valves and hydrants in the system, to prevent the resulting water-hammer from breaking this thin steel pipe, which is now over 60 years old. A few years ago, a break occurred in the pipe, which left the town of Bristol without water for a period of three days, while attempts were being made to weld a patch on the steel plate.

Water Pressures and Fire Flows

The static pressure in the village is approximately 50 lb. Flow tests, made by the New Hampshire Board of Underwriters, indicated that only 690 gal per min would be available in the case of a fire in the downtown area, whereas a flow of 2,500 gal per min is desirable. Similarly at the Dodge Davis Mill, located about ¾ mile above the center, a flow of only 690 gal per min was observed under test, where 2,000 gpm are required for adequate protection. Hydraulic computa-

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FIG. 1.—TOPOGRAPHICAL MAP OF BRISTOL, N. H.

tions indicated that a much larger quantity of water should be available, provided there were not other factors involved.

During the progress of the investigation, it appeared that one of the valves in the mill yard had been left open for a number of years

and had discharged over 100,000 gal per day directly to the river. This leak accounted for much of the apparent loss of capacity of pipe lines.

Quality of the Water

The quality of the water in Newfound Lake was excellent for many years, but the hazard of human pollution is now ever-present. Summer colonies developing along the shore aggravate the problem of increasing contamination of the lake water. Moreover, the growing demand for recreational spots in the State of New Hampshire has served to intensify the problem, through the competitive uses of attractive lakes by water-supply departments and recreational interests. Since the two developments are opposed to each other, it is clear that there is no easy solution to the situation and it would appear, at least for the smaller towns, that it may be desirable to obtain the domestic supply elsewhere.

Since Newfound Lake presents such an attractive recreation center, it would be impractical for the Department of Health to police this area at all times and to prevent persons of all ages from bathing in the lake. Chlorination was required several years ago for the protection of the customers, but the Department of Health has ruled that filtration of the supply would be required if the town were to continue using the water.

Factors Affecting Planning of Water-Works Improvements

After the failure of the steel pipe line and the resulting three-day drought, the Public Service Commission ruled that the customers must be supplied continuously in order for the Aqueduct Co. to hold its franchise.

Due to the low static pressure in town, the long pipe line leading from the lake, the loss of fire-fighting facilities through breaks, and the inadequate fire reserve, the New Hampshire Board of Underwriters ruled that the pipe line from the lake must be renewed, additional local storage be made available, or other suitable arrangement made, to assure continuous service. Failure to make the necessary improvements might involve an increase in fire-insurance rates.

The increasing contamination of the lake by the summer-colony

population led the New Hampshire Board of Health to rule that water must be filtered, if the town of Bristol were to continue using Newfound Lake as a source of water supply.

The Bristol Aqueduct Co., faced with an expenditure of $50,000 to $100,000, was reluctant to start the construction of the filtration plant, the erection of a steel standpipe, and the program of pipe replacement. Fortunately the town took advantage of conditions to purchase the water system in 1948.

New Source of Supply

Exploration for ground water, to be obtained from wells, was limited by the financial condition of the Bristol Aqueduct Co. and the areas investigated were confined to locations adjacent to the existing pipe lines. Only one of the many test wells indicated the possibility of securing water locally from underground sources. The quality of water from this test well was poor, as the high content of iron would render such a supply impractical.

Under the direction of the town, a successful test well was driven, off Route 104 near the edge of Danforth Brook, whose watershed at this point is less than two square miles and is sparsely populated.

New Gravel-wall Well

A few feet from the site of the test well, a new gravel-wall well was installed to a depth of approximately 49 ft. The inner casing and screen were of 12-inch diameter, the gravel envelope having a diameter of 24-in. at the ground surface, with concrete seal ot 36-in. diameter. A temporary pump was installed and the well was tested for a period of two days. The rate of pumping was 350 gpm for 30 hours and 500 gpm for the remainder of the test. The static pumping level was 5 ft. The pumping level at 350 gpm was 10 ft and the final drawdown at 500 gpm was 12 ft. One observation well was provided, approximately 75 ft southeast of the large well. The maximum drawdown on the observation well during the test was 11 ft.

Piping Connections to Town

An 8-in. pipe, about 5,000 ft long, was laid from the new well along Route 104 and connected to the town piping system near Spruce

St., where the existing pipe was 8-in. in diameter. Re-connections were made at Merrimack St. to the old 4-in. pipe line.

A new 10-in. main was laid in Hillside Ave., connecting the standpipe with the 10-in. cement-lined steel pipe on Lake St. Branch connections to the existing pipes in Green St. and North Main St. (the old Turnpike Road) were also made, to improve the fire-fighting facilities.

Standpipe

A new welded steel standpipe (see Fig. 2) was erected on Sugar Hill on a reinforced-concrete foundation, opposite the end of Hillside Ave. The standpipe has a height of 32 ft and a diameter of 37 ft, and was furnished and erected in accordance with the AWWA Standard Specifications. The roof is of copper-bearing steel and the structure is painted with three coats of paint. Basic lead chromate was used for the shop and interior coats. The exterior was finished with two coats of aluminum paint.

The high-water level of the standpipe is approximately 30 ft above the level of Newfound Lake, in order to afford an additional pressure of 15 lb over the system.

The standpipe was erected on the site with an approach grade varying from 30 to 50% up from the Old Turnpike. The steel-erection contractor had no difficulty, however, in skidding the plates into position.

Pumping Station

The pumping station, (Figures 3 and 4) measuring 16 ft by 18 ft inside the walls, is somewhat larger than the usual design, as recent practice indicates the desirability of more space for electrical equipment and engine appurtenances. The larger station also permits the gate valve and meter to be included above the motor floor for easy access.

The pumping station was constructed with concrete foundation, brick side-walls and concrete-slab roof. A metal-covered scuttle with louver ventilator and adjustable doors was provided in the roof over the location of the well, to permit setting the pump and ventilating the motor and gasoline engine.

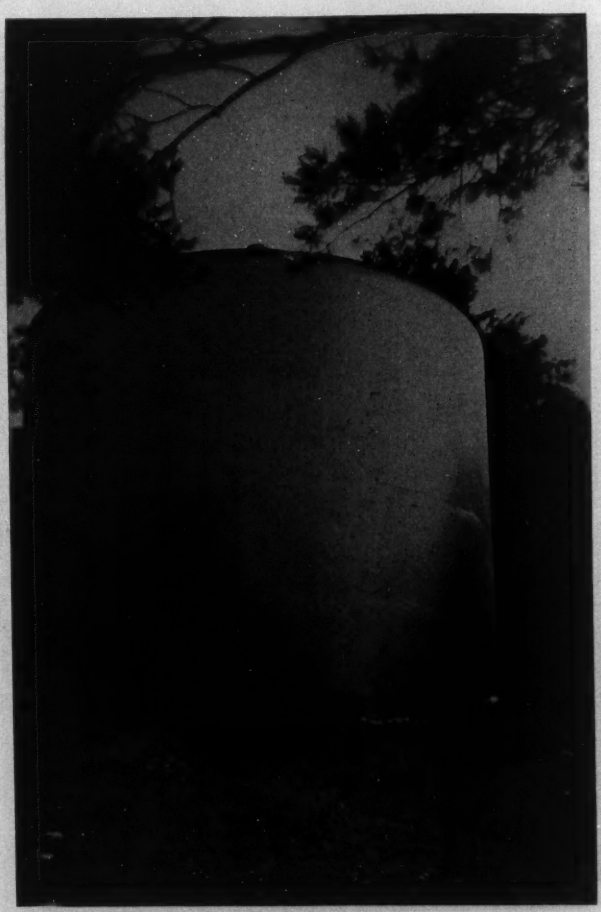

FIG. 2.—VIEW OF STANDPIPE.

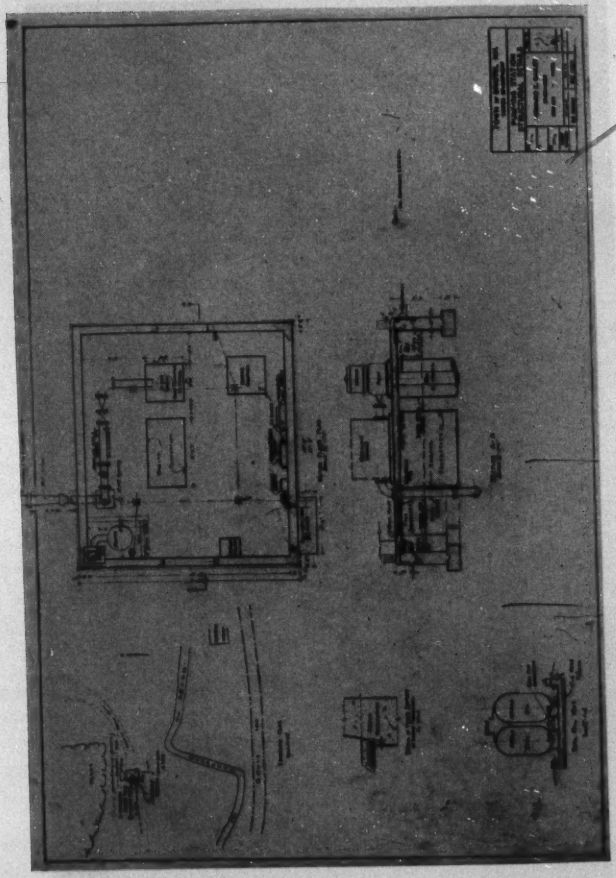

FIG. 3.—PLAN AND DETAILS OF WATER PUMPING STATION.

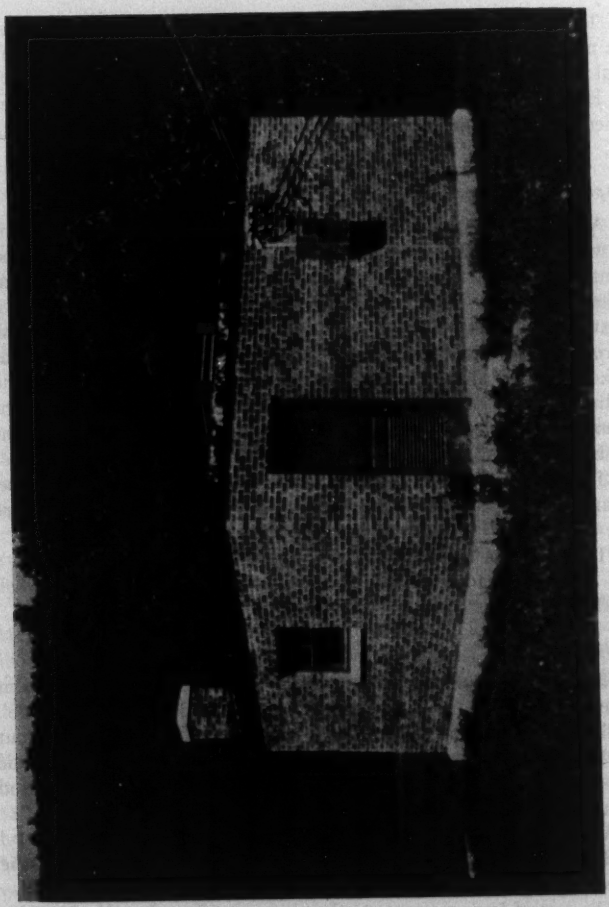

FIG. 4.—VIEW OF COMPLETED PUMPING STATION.

Two ventilated aluminum-sash windows were provided, as well as a metal-clad door with louvers in the lower panel. An adjustable metal sheet provides regulation of the ventilation in the door louvers.

Heating in the station is furnished by a gravity-type oil burner, connected to a fire-lined-clay-brick chimney, built as part of the station wall.

Pumping Equipment

A turbine-type, vertical centrifugal pump has been provided in the well, with dual drive, consisting of a 25-hp electric motor, mounted on top of the pump shaft, together with auxiliary gasoline engine, connected at right angles through gearing. The motor is operated at 220 volts, 3-phase, 60-cycle current. An enclosed, electrical control unit, mounted in a single cabinet, includes the incoming line breaker, branch circuit breaker, reduced-voltage motor starter, and building service connections. The operation of the pump will be automatic, the electric controls being actuated by pressure in the distribution system.

The auxiliary gasoline engine is a 6-cylinder, Ford industrial-type, unit and is equipped with radiator cooling and attached gasoline-storage tank.

The pump is rated at capacity of 350 gpm at 1,750 rpm, at a total dynamic head of 80 lb, and will pump water from the well directly into the distribution system.

Results

The new additions to the water system will allow the abandonment of Newfound Lake as a source of supply, and will furnish cool, unpolluted water to the consumers at an increase of pressure of about 15 lb. The standpipe will provide about 2½ day's storage for domestic water supply, or 1,000 gpm for fire-fighting purposes for a period of four hours.

An additional well is contemplated in the near future and consideration is being given to extending the system to include the summer cottages around Newfound Lake.

The cost of improvements to the system is approximately $70,000.

GROUND-WATER SUPPLY FOR NEW BRITAIN, CONNECTICUT

BY GEORGE W. WOOD*

[*Read February 16, 1950.*]

BEFORE describing in detail the ground-water supply for the city of New Britain, perhaps it would be well to give a brief description of the city's water-supply system.

Our water-supply system originated in 1857 with the construction of a small dam, creating Shuttle Meadow reservoir at a point about 3 miles southwest of the center of the city (see Fig. 1). The drainage area tributary to this reservoir was only 1.17 sq mi.

Several improvements have been made at this location. Two canals were constructed, one to the east of the reservoir and one to the west. These two canals, with a total length of 15,000 ft, intercept the flow of water in several small brooks and divert this flow to the reservoir. This increased the drainage area to 2.94 sq mi.

The height of the dam has been increased until, at the present time, Shuttle Meadow reservoir has a total storage capacity of 1,290 mil gal.

In 1897 a double, 20-inch pipe line was constructed from Shuttle Meadow to Roaring Brook in the town of Wolcott. In 1904 the Wolcott reservoir, with a drainage area of 2.45 sq mi and a storage capacity of 170 mil gal was constructed. The flow-line elevation of this reservoir is 767.8 ft above sea level.

Water from this reservoir is discharged into the original Roaring Brook channel, whence it is carried down the mountain side to the intake of the double, 20-inch pipe line. The flow line of this intake is 557 ft above sea level.

This pipe line crossed three valleys on its route to Shuttle Meadow. The first of these valleys is known as the Eight Mile River valley, the second as the Quinnipiac River valley, and the third as the Patton Brook valley.

*Chief Engineer, Board of Water Commissioners, New Britain, Conn.

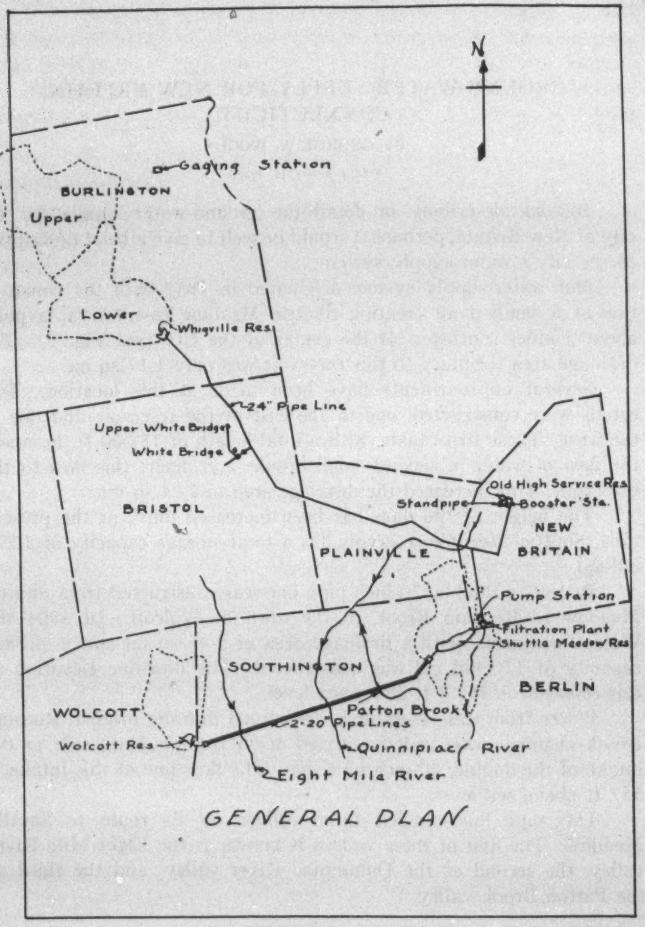
N
Gaging Station
BURLINGTON
Upper
Lower
Whigville Res.
24" Pipe Line
Upper White Bridge
White Bridge
BRISTOL
Old High Service Res.
Standpipe
Booster Sta.
NEW
BRITAIN
PLAINVILLE
Pump Station
Filtration Plant
Shuttle Meadow Res.
SOUTHINGTON
BERLIN
WOLCOTT
Patton Brook
2-20" Pipe Lines
Wolcott Res.
Quinnipiac River
Eight Mile River
GENERAL PLAN

FIG. 1.

The Patton Brook valley is about 220 ft above sea level and the point where the pipe line crosses the brook is 6,600 ft west of Shuttle Meadow. About 1,200 ft west of Shuttle Meadow the two 20-inch pipe lines unite into one 30-inch line. The invert of the pipe line at this point is 412 ft above sea level.

The reason for giving all these details on this particular area at this time is that we are now completing a well in this valley, which will be described later.

In 1908 a 24-inch pipe line about 10 miles long was constructed from the city northwest into the town of Burlington. Water was diverted from the Whigville Brook until 1910, when the Whigville reservoir was constructed. This reservoir, although it collects water from 4 sq mi, has a capacity of only 64 mil gal. It really cannot be classed as a storage reservoir, but only as an overgrown intake.

Perhaps you have already noticed a peculiarity in regard to the Wolcott and Whigville developments. The Wolcott development has a drainage area of 2.45 sq mi, a storage capacity of 170 mil gal and a pipe-line capacity of 12 mgd to Shuttle Meadow, whereas the Whigville development has a drainage area of 4.0 sq mil, a storage capacity of 64 mil gal and a pipe-line capacity of 6.3 mgd to Shuttle Meadow.

During the progress of a leak survey in 1941, both of these lines were tested and in both cases the coefficients determined ranged between 90 and 94.

In 1920, under the supervision of Allen Hazen, numerous test wells were drilled in a valley about 3.3 miles below the Whigville reservoir and in the northeastern section of the city of Bristol.

The flow line of the Whigville reservoir is 570 ft above sea level. The terrain drops rapidly to the south. About 5,000 ft south of the reservoir the elevation is 350. At the area where the test wells were drilled the elevation is 250 ft above sea level.

In this valley there is a brook system, consisting of the old Whigville Brook, the Wildcat Brook, Falls Brook and Polkville Brook. All these brooks originate in high, rocky areas and then meander through this broad, flat sandy valley. These brooks all combine to form the Copper Mine Brook or, as it is more correctly known, the North Branch of the Pequabuck River.

After considerable study it was decided to construct a ground-water supply a short distance above the confluence of the Polkville Brook and the Copper Mine Brook (see Fig. 2).

A canal, 1,200 ft long was constructed, connecting the two brooks. About 50 ft south of this canal and parallel to it 20 8-inch wells were installed.

These wells consist of an 8-inch casing with a screen 15 ft long at the bottom. The average depth of these wells is about 40 ft. A 4-inch suction pipe extends down the inside of each well and at the top connects to a header line, the first portion of which is 12-inch pipe and the remainder 16-inch pipe.

The 16-inch header line terminates in a large concrete well, known as the caisson. This caisson is 50 ft in diameter and about 28 ft deep, measured from the original ground level. The wall of this caisson is honeycombed with 3-inch pipes, spaced on 6-foot centers. There is no bottom to this caisson.

A 16-inch line leads from the caisson to the pump station. The original installation consisted of a horizontal duplex pump of 2.8-mgd capacity, operated by a 150-hp, 2-cylinder Diesel engine. A vacuum pump was connected to the 16-inch header line just before this line entered the caisson.

As the water was pumped from the caisson and the water level dropped, the difference in level between the inside and outside of the caisson started water flowing from the wells.

This original installation was intended as an auxiliary supply. For the first few years it was not used very much, but, as consumption increased, it was called upon more and more. In 1931, after pumping for several weeks, the canal and the Copper Mine Brook were absolutely dry. It became necessary to resort to part-time pumping.

A number of 2-inch observation wells had been left in place at the time the 8-inch wells were installed. Several more observation wells were drilled and daily readings on the water levels were taken. While drilling these wells soil samples were also taken.

The 16-inch header line was tapped and a flow test taken, to determine the quantity of water being delivered from the wells. It was discovered that 41% of the water being pumped from the caisson was coming from the caisson itself.

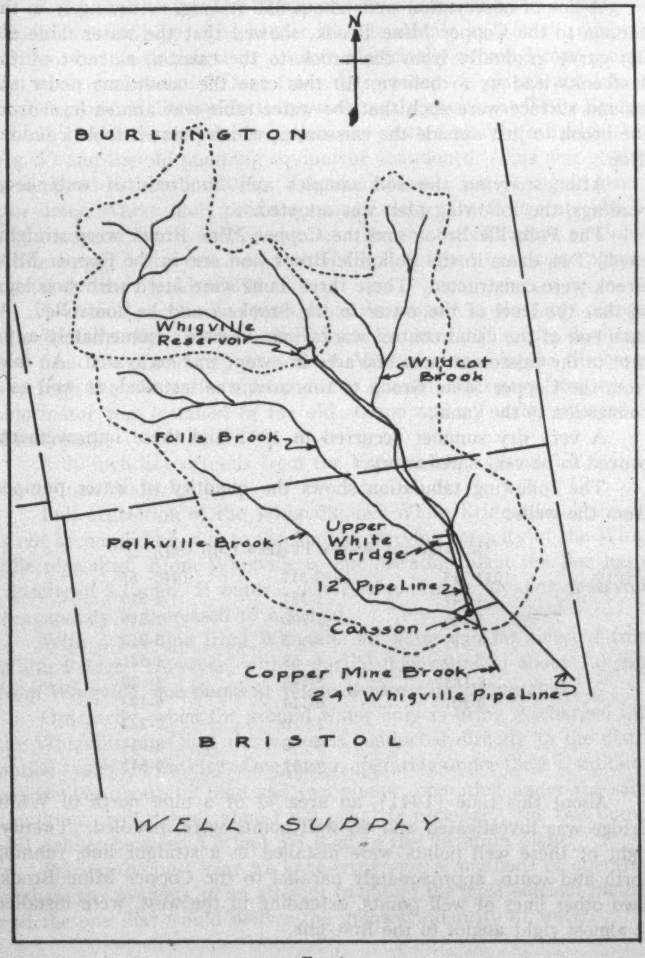
N
BURLINGTON
Whigville Reservoir
Wildcat Brook
Falls Brook
Polkville Brook
Upper White Bridge
12" Pipe Line
Canisson
Copper Mine Brook
24" Whigville Pipe Line
BRISTOL
WELL SUPPLY

FIG. 2.

A line of observation wells about 250 ft long, extending from the caisson to the Copper Mine Brook, showed that the water table did not curve gradually from the brook to the caisson, as most of the textbooks lead us to believe. In this case the conditions under the ground surface were such that the water table was almost level from the brook to just outside the caisson, at which point it took a sudden drop.

After studying the soil samples and hundreds of water-level readings, the following plan was adopted.

The Polkville Brook and the Copper Mine Brook were straightened. Two dams in the Polkville Brook and one in the Copper Mine Brook were constructed. These three dams were fitted with stop logs, so that the level of the water in the brooks could be controlled. At each end of the canal control works were erected. Immediately adjacent to the caisson an area one acre in extent was excavated. An inlet from the Copper Mine Brook to this area was installed, as well as a connection to the canal.

A very dry summer occurred in 1941 and these improvements proved to be very satisfactory.

The following tabulation shows the quantity of water pumped from the wells:

QUANTITY OF WATER PUMPED (Mil Gal)

1923- 15	1930-317	1940- 85
4-147	1-357	1-510
5-196	2-290	2-316
6-219	3- 5	3-233
7- 0	4- 68	4-531
8-183	5-148	5- 20
9-301	6-114	6-193
	7- 0	7-222
	8- 0	8-244
	9-157	9-642

About this time (1941), an area ¾ of a mile north of White Bridge was investigated and 66 well points were installed. Twenty-eight of these well points were installed in a straight line, running north and south, approximately parallel to the Copper Mine Brook. Two other lines of well points, extending to the west, were installed at almost right angles to the first line.

These well points are connected to header lines, consisting of 8-inch Transite pipe. The header lines terminate in a small pumping station. In this station there are two electrically driven 1-mgd pumps and a vacuum pump. Water from these pumps is discharged into a 12-inch pipe line that conducts the water to the caisson at White Bridge.

In 1943 a new pumping station was erected at White Bridge (see Fig. 3) and the old pumping equipment abandoned. This new station is equipped with two, 300-hp, Fairbanks-Morse, Diesel engine generator units. These units produce enough electricity to operate two 3-mgd pumps at White Bridge and also the two 1-mgd pumps at Upper White Bridge. The two 3-mgd pumps are designed to operate against a total dynamic head of 298 ft.

A 16-inch suction line leads from the caisson to the large pumps. The discharge line is a 14-inch line and is connected to the discharge line from the abandoned station. A Venturi meter in the discharge line from the old station measures the quantity of water pumped. A chlorinator was installed in the old station and all water pumped is chlorinated.

A 20-inch line extends from the Venturi meter about 1,100 ft to the 24-inch Whigville line.

Full utilization of the Whigville and White Bridge developments is not accomplished, due to the limited carrying capacity of the Whigville pipe line. From Whigville to our filtration plant the line has a capacity of 5.1 mgd. If water is delivered to Shuttle Meadow reservoir, the capacity is increased to 6.5 mgd.

With a full line from Whigville no water can be diverted from White Bridge. However, with a partial flow equal to about 3.0 mgd from Whigville, one pump at White Bridge can be operated.

Ordinarily, when the ground water only is being discharged into the Whigville pipe line, this water is conducted directly to the distribution system in the city. One pump, operating under these conditions, will deliver about 3.5 mgd and two pumps, operating under the same conditions, will deliver almost 6.0 mgd. If necessary, the two pumps will deliver between 5.0 and 5.5 mgd to the filtration plant.

During the past year we have tried several methods of operation of these two systems, in an attempt to obtain the most efficient method and the one that would deliver the greatest quantity of water.

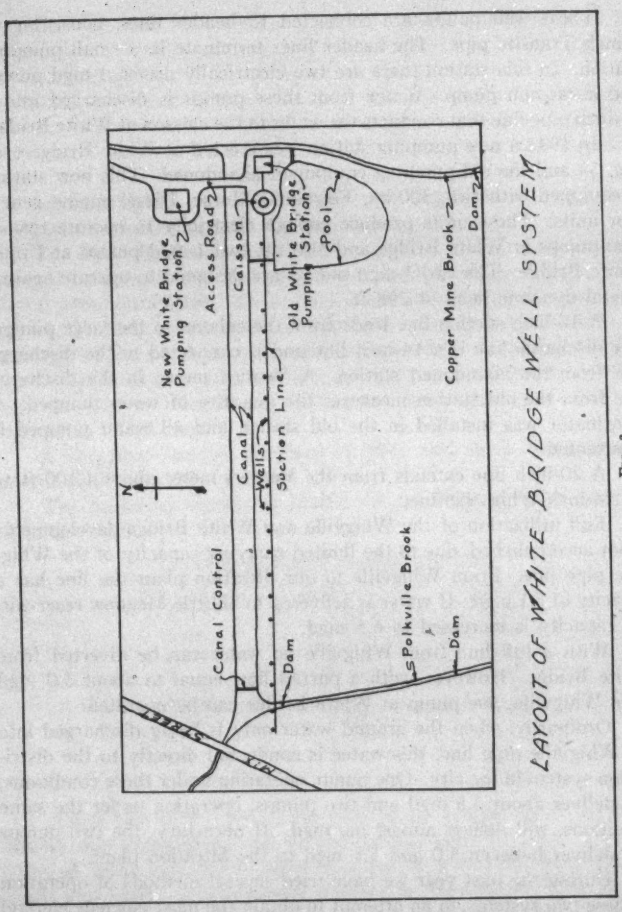
New White Bridge Pumping Station
Access Road
Caisson
Old White Bridge Pumping Station
Pool
Copper Mine Brook
Dam
N
Canal
Wells
Suction Line
Canal Control
Dam
Polkville Brook
Dam
LAYOUT OF WHITE BRIDGE WELL SYSTEM

FIG. 3.

The original purpose of the White Bridge installation was to pump water from the Copper Mine Brook during periods of high flow and to pump from the wells during the dry periods. Taking advantage of the water available during the periods of high flow has not been done, due to the lack of storage for this water and the small capacity of the pipe line.

The city obtained full rights on the Copper Mine Brook and may take all the water available. Considerable water is lost each year. The drainage area tributary to White Bridge is slightly over 10 sq mi. Whenever water is spilling at the Whigville reservoir, the drainage area becomes about 14 sq mi.

Between Whigville and White Bridge there is no reservoir site. In order to collect the flood flows that are now lost, it would be necessary to find some location where storage could be created and, with high-capacity pumps, to divert these flood flows. Reservoir sites are not numerous and construction is costly.

As we all know, the past summer was deficient in rainfall. In June our rain gages recorded slightly over ½-inch of precipitation. Consequently, the pumps at White Bridge were put into operation on June 20. From this date until December 31 they were operated continuously with the exception of 12 days, during which time water was being diverted from Whigville. During this period of 194 days, 642 mil gal of water were pumped from the wells. This is at the rate of 3.3 mgd.

The pump station was shut down from December 31 to January 5. Whigville water was diverted during this period. On January 5 operations were resumed at White Bridge. This time, however, a combination of White Bridge and Whigville was used and is still in operation. About 3.1 mgd are being diverted from Whigville and about 2.6 mgd from White Bridge. Because of the Whigville water the diversion is being delivered to the filtration plant. In January 70 mil gal were diverted from White Bridge.

At one time this past summer the excavated area adjacent to the caisson was almost dry. Pumping was increased and this area was dried out and cleaned. After cleaning, pumping was returned to normal and the pond started to rise again.

No readings on water levels were taken in the observation wells.

The depth of water in the canal, the pond, the brook and the caisson indicates to us very closely where we stand. Hourly readings are taken in the caisson and, when the water level drops to a certain point, we know that pumping will have to be decreased. This area is extremely susceptible to light showers. Within a very short time after a shower the effect is noticed at the pump station. There is some rise in the water level.

At the present time, even after such a long period of almost continuous pumping, there is water passing the station, spilling over the stop logs and continuing on downstream.

Let us now travel several miles to the south into the town of Southington, through which the Wolcott pipe line passes. This pipe line, as mentioned in the first portion of this paper, crosses three valleys. Several 8-inch test wells were drilled in these valleys, close to the pipe line.

Eight wells, drilled across the Eight Mile River valley, did not give any indication of the presence of a good ground-water supply. There is about an 8-square-mile area tributary to the pipe line in this valley. Most of this valley consists of sand and gravel and should be productive, but evidently we did not find the correct location. The eight wells drilled did not reach rock.

In the Quinnipiac River valley, a seismic survey was run across the valley and indicated rock to be at least 100 ft below the surface at a point about 100 ft east of the river. The area tributary to this point is about 15 sq mi and consists for the most part of a wide, flat sandy plain.

Two wells were drilled and some water was found. The sand, however, is fine and probably several wells would have to be installed in order to get a respectable supply. It would require a rather large property purchase of a truck farm. As the owners are not willing to sell at a reasonable figure, this location is being bypassed for the time being.

The third and last valley that the Wolcott pipe line crosses is that traversed by the Patton Brook. The Eight Mile River and the Quinnipiac River flow in a southerly direction, but the general direction of Patton Brook is to the north. About 1.5 miles from the point at which the brook crosses under the pipe line, it joins the Quinnipiac

River. The drainage area in this case lies to the south of the pipe line and covers about 1.8 sq mi.

On the east edge of this valley there rises a hard rock ridge about 200 ft high. There is a sharp drop to the floor of the valley, which, however, is not as flat as the floors of the Eight Mile River and Quinnipiac River valleys. It is more irregular with several low, rounded hills.

The first test well drilled in this area was at the eastern edge of the valley floor. Rock was encountered at 16 ft and some water was in evidence. The second well was drilled about 1,900 ft west of well #1, and in this well rock was 23 ft from ground level. A four-hour test produced 330 gpm, with almost immediate recovery.

The next three wells were drilled in an area south of the pipe line and approximately 700 ft west of well #2. These wells were drilled 63, 68.5 and 68 ft, respectively, without hitting rock. Yield tests on two of these wells produced 350 gpm and 340 gpm. A four-day test on the third well produced 427 gpm with a drawdown of 8.5 ft.

It was then decided to try a well in this same general area, but on the north side of the pipe line. Water was encountered about four feet from ground level. Drilling was carried to 58 ft. The casing was withdrawn to 47 ft and a four-day test was run, during which 523 gpm were pumped with a drawdown of 5.5 ft.

Considerable difficulty was experienced in obtaining a right of way into the well site and in obtaining a small piece of property. There were several differences of opinion between the two property owners and the city. Finally, after the city compromised by agreeing to pay a substantial sum of money, the right of way and the piece of property were obtained.

A 12-inch well was decided upon and the Stephen B. Church Co. of Seymour, Conn., was the successful bidder for installing the well.

Samples taken from the 8-inch test well indicated gravel and some coarse material down to about 30 ft. Drilling in this material was not difficult. From the 30-foot depth to the 58-foot depth drilling was slightly more difficult.

To install the 12-inch well the contractor started with a 48-inch casing, which was carried down 25 ft. There was gravel, certainly, but mixed with this gravel there were numerous cobbles. Several of

these cobbles were as much as 15 in. in diameter and, of course, they persisted in being under the rim of the casing.

At the 25-foot depth the casing was reduced to 36 in. The 36-inch casing was driven to 32 ft, where hardpan was encountered. In order to determine the thickness of this layer of hardpan, a 10-inch casing was then used. This casing was driven to the 60-foot level and rock. There is about a one-foot layer of water-bearing material just above the rock.

The finished well consists of a 12-inch casing with a 10-foot long, 80-mesh Johnson well screen, set with its lower end at the 32.5-foot level. The 10-inch hole through the hardpan was filled with coarse gravel as the 10-inch casing was withdrawn. As the 36-inch and 48-inch casings were withdrawn, coarse gravel was allowed to settle around the screen and part-way up the 12-inch casing. About 12 cu yd of gravel were used.

Development consisted of alternate surging and pumping. Very little sand was pumped.

Following development a 72-hour yield test was conducted. The pumping rate for the first 60 hours was 1.050 gpm and the drawdown was 8′-2″. The rate was then increased to 1,250 gpm and continued at that rate for the remaining 12 hours. The maximum drawdown was 10′-2″.

Thirty minutes after pumping had stopped the water level was 3′-7″ from the original water level. Twenty-four hours later the water level was 0′-9″. The second day after the test the water level was back to normal.

No observation wells were available for a study of the water table. Readings were taken, however, in the brook about 100 ft away and in a small ice pond about 700 ft distant from the well. No lowering of the water level was observed in either case.

A concrete and brick pumping station has been erected, but the pumping equipment has not yet been installed. The starting requirements are very strict, necessitating the use of a slip-ring motor, with starting current limited to 150%. It is also necessary to install 1,500 ft of underground cable.

The equipment is to consist of a deep-well pump of 900-gpm capacity, driven by a 75-hp motor. Control is to be automatic, consist-

ing of a time switch and safety device. Output is to be measured by a Propello-type meter.

The building has been made large enough so that chlorinating apparatus may be installed if ever needed.

In order to take advantage of this supply this past fall, a pump unit was rented and connected to the well. This unit consisted of a centrifugal pump, driven by a 4-cylinder Diesel engine and mounted on one base. For approximately three months 1 mgd were pumped from this source. The discharge pressure was about 85 lb. The vacuum gage on the suction registered 15 in. at the beginning and reached a maximum of 22 in.

Water was discharged into one of the 20-inch pipes of the Wolcott pipe line, while the other 20-inch pipe was carrying water from the Wolcott reservoir.

We do not expect this well to produce 900 gpm throughout the year. Operation at the beginning will be confined to the dry portion of the year. Observation wells will be installed and a study of the water-table levels will be made.

We are fully aware of the deplorable conditions existing in certain sections of the country, due to overpumping, with no regard to the replenishment factor. For our own protection, as well as for the benefit of others, we intend to follow this procedure.

At White Bridge no trouble has been experienced with the quality of the water, in spite of the fact that there are several farms on the drainage area and also a housing project. No trouble is expected in the Patton Brook area.

The table on page 157 gives the characteristics of the water from White Bridge and from Patton Brook. The analysis of the White Bridge water was made on October 11, 1949, 114 days after the pumps at White Bridge were put into operation.

The water consumption of the city for the years 1926 to 1949, inclusive, is shown graphically in Figure 4.

In this paper the writer has tried to give a clear picture of the water supply system of the city of New Britain—particularly the ground water supply. No one individual can be given the credit for developing our system. It is the composite result of the thinking,

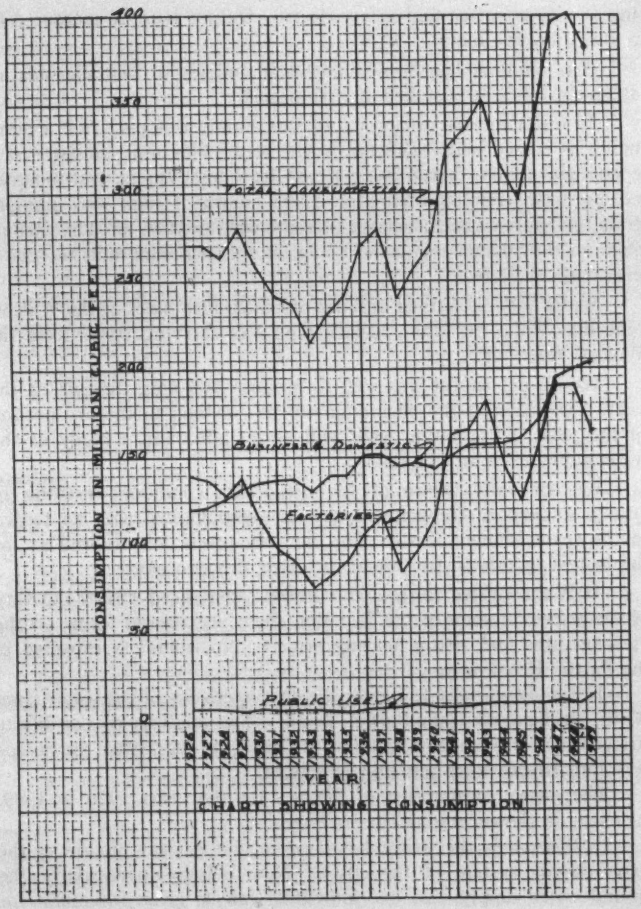
400
350
300
250
200
150
100
50
0
CONSUMPTION IN MILLION CUBIC FEET
TOTAL CONSUMPTION
BUSINESS & DOMESTIC
FACTORIES
PUBLIC USE
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
YEAR
CHART SHOWING CONSUMPTION

FIG. 4.

	White Bridge	*Patton Brook*
Color	5	3
Odor	0	0
Turbidity	0	0
Nitrites	0.001	0
Nitrates	0.60	1.50
Ammonia	0	0.04
Albuminoid	0.024	0.032
Chlorides as Cl	4.6	4.6
Normal chloride	1.9	2.0
Hydrogen-ion concentration	6.4	7.1
Alkalinity as $CaCO_3$	19	51
Total hardness as $CaCO_3$	42	74
Iron as Fe	0.15	0

and of putting into practice the thoughts, of people too numerous to mention.

Discussion

Francis H. Kingsbury (Boston, Mass.). I think Mr. Wood mentioned an installation where he apparently siphoned over from a group of tubular wells into a large well. Is there any tendency, during the non-pumping period, to lose any water into the surrounding ground?

Mr. Wood. From measurements we took a number of years ago when no pumping was being done, the level of the water in the caisson and the water level outside the caisson were just the same. They remained the same when no pumping was being done. As soon as pumping starts, that comes right up and approaches the level of the ground-water table. I might say, while we have been pumping in the last month and a half from one pump, we were not using the Upper White Bridge well system and 3 to 5 mil gal of water were going down the brook past the station, that we could not utilize.

Arthur L. Shaw (Boston, Mass.). There is one feature that Mr. Wood did not mention, which I should like to ask about. He did speak of the small, 2- or 2½-inch tubular wells in the Upper White Bridge development. I believe those wells were somewhat novel and they are of the so-called Moretrench type, which is a construction type of well, not usually thought of for a permanent installation. I

should like to ask Mr. Wood if he has had occasion to pull any of those wells, to see how they are standing up.

MR. WOOD. We have not pulled any of them. We have backwashed them. We have a Moretrench unit, which we have used to clean out these 20-inch wells, and also backwash these well points. We have not pulled out any, to know what condition they are in. I might say that Mr. Shaw did some work for us.

WATER METERS

BY JAMES A. SWEENEY*

[*Read at Superintendents' Round Table, March 16, 1950.*]

THE water meter is the cash register of any water department. There are also other reasons for its use. First, it tells us how much water is pumped into the distribution system at the pumping stations. Secondly, it is used to measure and record accurately the passage of water through the distribution lines and to record the customers' use, to enable us to render bills and to reduce waste. It also enables us to compare our pumping records with consumption and to arrive at a figure for "unaccounted-for water."

Many types and kinds of meters are made and used, and each type is designed for a special service, as disc, current, Venturi, etc. Departments may use certain makes of meters for any of the following reasons: the internal construction, the metal, or the very fine machine work, and also for the time required to make repairs.

Meters

The Manchester Water Works has at the present time eight different kinds of meters, with a total of 13,500 in service. We are gradually reducing the number of kinds by eliminating some obsolete makes and looking forward to the time when we shall utilize not more than two kinds for general domestic use. In this way we could keep a larger stock of repair parts on hand and less repair equipment.

All new meters are tested when delivered and separate cards are made out, showing serial number, kind, size, date purchased and price, together with the test report. The history of each meter is added to this card, being taken from order cards turned in by the workmen.

Installation

Some study must be given to arrive at a correct size and kind of meter to be installed in a service, in order that the meter may not be over- or under-sized. This, of course, applies more to commercial or

*Assistant Superintendent, Water Works, 287 Franklin St., Manchester, N. H.

industrial use than to an average residence. Normally a ⅝-inch meter will give satisfactory service to the average home. However, some of the newer houses, using flush-valves instead of a tank-type closet, must have a larger service and meter. In this event it is our policy to charge the owner of the residence the difference in cost of service material, plus the cost of a meter that is larger than average house size.

The modern method of piping at Manchester is for the service pipe inside the basement to run vertically and hang to the under side of the floor joists. This allows easy accessibility for making quick replacements and repairs and is an advantage to the Water Works as well as to the householder. A great deal of the future cost of maintenance of meters on the premises will depend on how the original installation is made. We require the owner to furnish a Copperhorn to hold the meter, which is installed about 2½ ft above the floor in the vertical line, with a stop valve on both sides. Copperhorns are also required on all relaid services. Our experience since 1933, after using more than 3,500 of these horns, has resulted in more accurate and faster meter reading, as well as greater facility in changing meters and making minor repairs on the premises. We all remember the old method of setting the meter below the cellar floor and protecting it with a wooden box, which was often used for a step to a shelf above the meter. After some years the box would deteriorate and we have known of injuries to persons caused by this "step." Also, I have known the box to be used as a hiding place for "bootleg liquor."

Maintenance

In order to maintain the income received at the time of the original installation, it is necessary to set up a meter service department. Our repair equipment consists of the following: Clark Tester with Testrate indicator, tank and scales, suitable to test three ⅝-inch, or two ¾- and one 1-inch, and one 1½- and one 2-inch sizes; one electric buffer for cleaning external parts of the meter, and one electric drill press, together with storage bins for meters and parts. We also have a 3-inch portable test meter for testing large meters in place.

Some years ago we established a schedule to remove, test and overhaul 10% of our meters each year. I must admit we have never quite accomplished this. In the past, too little thought has been given

to the average meter-repair space and equipment in the majority of water departments. We are in the process of having a new office, garage and storage building, and are planning a good-sized meter room in the office building. We intend to equip this shop with modern facilities for repairing and testing, and are looking forward to this new construction this year. I feel the meter-repair shop should be large enough to hold all necessary equipment and facilities for cleaning, repairing and refinishing meters, together with adequate space for parts; in other words, a place to be proud to show our customers.

During the winter months we add one meter crew of two men to our regular work, but we are seldom able to keep them on regularly, because our severe winters cause service pipes to freeze and heavy snow-storms keep our whole crew busy fighting the elements, instead of removing meters for test.

The majority of our meter-repair work, such as stopped meters and spindle and coupling leaks, is reported by the meter readers. We find the majority of our stopped meters due to tuberculation or rust loosened from the mains or service; spindle leaks usually due to worn packing or the spindle itself, and coupling leaks due to deteriorated gaskets.

All meters that are removed because of age, or for other reasons, go through a series of tests as follows: 8, 3-½, 1 and ¼ gpm. The report is then transferred to the "history" card. After a meter is repaired, the date is stamped on the inside of the cover for future reference and each meter is given a coat of bronze before leaving the shop.

Each year we have some meters damaged by the backing of hot water through the meter, due to the high water temperature's causing an increased pressure, greater than the city pressure. This, of course, means that either there was no relief valve, or it was improperly installed. Unless this increased pressure could get back into the main, very serious damage could be caused to the building and the occupants. In each case we notify the owner and send a bill for repairs. We call his attention to how serious this could be and request the owner to remedy this condition at once. A copy of this letter is also sent to the City Plumbing Inspector, in order that he may make an inspection and see that such conditions are corrected. In two places we have

installed meters with a special hot-water disc to overcome hot-water damage, and thus far they have proved very satisfactory, so far as damage to the meter is concerned.

Billing

With the exception of about 90 industrial customers, all of our meters are billed on a quarterly basis. The industrial meters are read and billed monthly, being allowed one third of the quarterly sliding scale. Our rates are as follows:

For the first 90,000 cubic feet per quarter @ 12¢ per 100; for the next 180,000 cubic feet per quarter @ 9¢ per 100; for all over 270,000 cubic feet per quarter @ 6¢ per 100; minimum bill $2.40 per quarter.

No attempt has been made to go into technicalities in this paper, but simply to show the overall picture as it looks to us in Manchester. I hope discussion by the members may bring out some things about meters that I have not mentioned, such as:

1. Carrying meters in trucks in below-freezing temperature;
2. Use of cleaning solution;
3. Use of cleaning equipment (sand or abrasive blast method);
4. Sanitation in meter shop;
5. Use of paper shims versus new balls;
6. Compound meters versus disc meters in parallel.

HOW GOOD IS NEW ENGLAND AS A LOCATION FOR MANUFACTURING?

BY ARTHUR A. BRIGHT, JR.*

[*Read March 16, 1950.*]

I AM going to answer the question, "How good is New England as a location for manufacturing?", by telling you what New England manufacturers themselves think about it. The opinions that I shall relay to you were reported to us in a survey completed last fall by the Federal Reserve Bank of Boston with the coöperation of the New England Council. We heard from 663 New England manufacturers, who employ more than 20% of all factory employees in the region.

Before I tell you what the manufacturers reported to us about their success in New England and about their prospects for the future, I should explain why we conducted the survey and what we were trying to discover.

Last summer we were concerned by what the current economic measures for New England were showing. In the non-manufacturing area, New England was performing as well as, or better than, the United States as a whole. But in manufacturing and related activities the picture was quite different. Manufacturing employment had declined more in New England than in the rest of the country during the preceding months. Freight carloadings were down more. Unemployment insurance claims had increased far more.

Manufacturing is of greater importance to New England than to any other region of the country, particularly in the three southern states of Massachusetts, Connecticut and Rhode Island. The jobs and income of more than two-thirds of the region's inhabitants depend directly or indirectly upon the factories.

With these facts in mind, we undertook to survey the opinions of manufacturers in the region about their present position and future prospects. We felt that their forecasts and evaluations would be of great significance in appraising the strengths and weaknesses of New

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England. For one thing, manufacturing executives are the men who can best judge the conditions under which they operate. For another, their policies and actions control or materially affect the income of the majority of New England's citizens and the probable trends in its manufacturing activities.

We had four principal questions about which we wished to obtain information:

1. How well did New England manufacturers maintain their sales during the first quarter of the year, in relation to those of their competitors outside the region?
2. How can the differences in sales performance be explained?
3. How well will New England manufacturers hold their competitive position in the moderate future?
4. How do the present locations of New England manufacturers affect their competitive position?

The first question was essentially, "How well have we been doing recently in relation to manufacturers outside New England?" Almost three-fourths of the companies which reported to us believed that their sales performance during the first quarter of 1949 had equalled or surpassed that of their industry. Less than one-tenth felt that their sales performance compared unfavorably with that of their industry, though one-sixth admitted that they did not know how well they had done.

If those claims were correct, three New England companies had surpassed their industry in first-quarter sales for every company that had fallen behind. If those claims were correct, we should have little cause for concern about the ability of New England manufacturers to hold up against competition outside the region. Unfortunately, we found that the region's manufacturers were over-confident about their sales success. For the country as a whole, manufacturers' sales were only 1½% lower in the first quarter of 1949 than they had been in the first quarter of 1948. For New England there was a 9% decline in manufacturers' sales.

Unless manufacturers know how they are doing in relation to their industry as a whole, they cannot measure their own performance accurately. We found that less than one-third of New England's manufacturers possess current sales statistics for their industry; only 10% have data on new orders received by their industry. It appears

tnat there is a strong temptation for companies to feel that they are doing as well as their competitors when they have no precise statistical information to the contrary.

Our second principal problem was to account for the claimed differences in sales success of New England manufacturers. We asked the participating companies for their own explanations for these differences. The companies which asserted that their first-quarter sales performance had surpassed that of their industry accounted for their superiority primarily in terms of market advantages, product advantages, and superior sales methods and organization. Very few of the companies accounted for their success in terms of price or cost advantages.

The companies which admitted poorer than average sales performance during the first quarter of 1949 stated that unfavorable market conditions were the single most important factor in their lack of success. They gave very great importance, however, to price and cost disadvantages. Difficulties with costs and prices were particularly outstanding among the producers of non-durables, which include, of course, manufacturers of textiles and shoes.

From these reports we reached the following conclusions:

1. Cost and price disadvantages are serious for a sizable number of New England manufacturers who are not keeping up with their industries.

2. Very few manufacturers in New England are able to outstrip their competitors outside the region *by virtue of* their lower costs and prices.

3. It is not absolutely necessary for a New England manufacturer to have cost and price advantages to compete successfully with outside producers. A favorable price-quality relationship may be more important to better sales performance than low prices alone. The formula for success in this region seems to be about as follows: build a better product adapted to the current needs of the market; establish favorable relations with customers and potential customers, and then sell the product aggressively.

The third major problem was, "How well will New England manufacturers hold their competitive position in the moderate future?" In general, New England manufacturers are fairly optimistic about

their ability to keep up with competitors outside the region. Eighty per cent of the companies expect their competitive position to remain the same or to become stronger during the next five years. The companies which expect to improve their position outnumber almost two to one those forecasting a weaker competitive standing. Optimism is highest in Connecticut, where the ratio between optimists and pessimists is more than four to one.

Since most manufacturers might be expected to be optimistic about their own future, the ratio of 1.4-1.7:1 between optimists and pessimists in five of the six New England states is cause for some concern. This is especially true since manufacturers as a whole are less optimistic about the future of *their industry* in New England than about *their own* future. As you might expect, the lack of optimism showed up most strongly in the textile and shoe industries.

The fourth principal problem was the evaluation of New England as a location for manufacturing activity. Since this topic provides the title for my talk, I shall devote the rest of my time to it.

The competitive advantages and disadvantages provided by New England are inevitably of tremendous importance in explaining the past success or lack of success of many of its manufacturers and their ability or inability to keep up with competitors located in other parts of the country in the future.

We found that, in the opinions of the 663 manufacturers, the advantages of their location in New England outnumber the disadvantages by two to one.

Here are the things that manufacturers like most about their present locations, in so far as they affect their competitive position in relation to producers outside the region:

Water supply,
Adequacy and dependability of electric power,
Attitude of the community,
Local living conditions,
Availability of labor force of suitable skills,
Character of the labor force,
Efficiency of machinery, and
Relations with labor.

The region offers some lesser advantages, in the opinion of its manufacturers, in climate, financial and distribution facilities, and plant sites and buildings. By far the most important location factor for New England, however, is the availability of a large skilled-labor force of high productivity and good character. This evaluation does not apply equally to every industry, of course. It is highest in the metalworking trades and lowest in the textile and shoe industries.

In the middle of the ranking we found such factors as location with respect to raw materials, wage rates, and location with respect to markets. About as many manufacturers consider each of these to be competitive advantages as feel they are competitive disadvantages. Accordingly, they are neutral factors for New England.

At the other end of the list there are five location factors which New England manufacturers as a whole, and Massachusetts manufacturers in particular, consider to be important, net competitive disadvantages. They are state and local taxes, non-tax laws affecting manufacturing activity, cost of fuels, cost of electric power, and cost of transportation.

What is the significance of these findings about locational advantages and disadvantages? Their significance rests on the distinction between those factors which are exclusively or primarily the product of our geographical location or natural resources and those which are man-made. If the geographical factors do not provide producers in New England with advantages over their competitors outside the region, and if manufacturing is to prosper, our manufacturers and communities must provide their own advantages.

Unfortunately, New England manufacturers see little net advantage in their geographical location, though as a whole they do not believe that it is an important competitive disadvantage. The advantages of fine water supplies, climate, and location with respect to foreign raw materials are offset by the disadvantages of power, transportation and fuel costs. Though influenced by man, these three items seem to depend fundamentally upon our lack of industrial fuel resources and upon our geographical position. Each is cited as an important competitive disadvantage by one-fourth to one-third of all companies. The other factors which depend primarily on geography are essentially neutral in their effect upon competitive position.

The degree of satisfaction with the natural location factors decreases from south to north. Producers in Connecticut and Rhode Island claim a net advantage from their location. In the northern states nature puts manufacturers at a competitive disadvantage, according to their reports.

With geography at best a neutral factor in the industrial future of New England, the location factors of man's own making take on great significance. We can be well satisfied with community attitudes and local living conditions, which are rated high throughout New England. We can also be pleased with the availability of the large skilled-labor force of high character throughout the region and the relations between labor and management. According to the responding manufacturers, the region has also done a good job in keeping its machinery and equipment up to date and competitive, though I have a feeling that there may be some wishful thinking in this connection by many manufacturers.

There are several other man-made factors, however, where New England must improve its position, if it is to retain its eminence as a leading manufacturing region. Even if plant buildings rank as a net advantage to New England producers as a whole, there is a sizable minority of 14% of the responding companies which assert that their buildings constitute an important competitive disadvantage.

Wage rates are cited as an important advantage by one-fourth of the companies and as an important disadvantage by one-fourth of the companies. The rest say that the wage rates they pay do not affect their competitive position in any fashion.

The most striking man-made competitive disadvantages, as seen by the responding companies, are the non-tax laws affecting manufacturing operations and the level of state and local taxes. These were the only two man-made factors for which more companies reported disadvantages than reported advantages. The discontent was particularly noticeable in relation to taxes, where 42% of all companies reported that the taxes they pay to their state and local governments constitute an important competitive disadvantage in relation to producers outside the region. Since taxes are reported to be the most important factor considered by manufacturers in choosing locations, this is a very serious situation. The complaints cannot be

dismissed as just "griping," since the opinions varied so much from state to state. The most dissatisfaction was voiced in Massachusetts, Rhode Island and New Hampshire. On the other hand, manufacturers in Connecticut and Vermont indicated that their state and local taxes constituted a net competitive advantage in relation to producers outside the region.

The significance of the ratios between advantages and disadvantages about which I have been talking is further emphasized by a comparison between these ratios and the increases in manufacturing employment during the last few years. The New England states with the highest advantage ratios showed the greatest employment gains from 1939 to 1947. Those with the lowest ratios showed the smallest gains in employment. Connecticut and Vermont head each list. New Hampshire and Massachusetts are in the middle. Maine and Rhode Island trail. The only New England states in which the gains in manufacturing employment from 1939 to 1947 kept close to the nationwide increase were Connecticut and Vermont.

To bring together our discussion of both the natural and man-made location factors, I shall list in order the location factors cited as disadvantages by the largest proportions of manufacturers, without relation to the number of other manufacturers who cited the same factors as advantages. These are the areas in which the region must concentrate its collective efforts:

State and local taxes—42%
Cost of transportation—34%
Location with respect to markets—27%
Cost of electric power—24%
Cost of industrial fuels—24%
Wage rates—23%
State and local non-tax laws—21%
Location with respect to domestic raw materials—19%
Plant buildings—15%
Plant sites—14%

It seems to me that within the last year the region as a whole has awakened to its difficulties and problems to a greater extent than ever before. More things are being done to remedy the disadvantages

and to exploit the advantages. Action has originated from many sources: from individual industries, from communities, from state governments, from banking groups, and from many other sources. I can only suggest a few recent approaches to the problem of increasing the area's attractiveness to manufacturing industry.

State and local taxes, as the most outstanding disadvantage, deserve first mention. The State of Massachusetts has had 18 separate special legislative commissions over the years to study tax problems. The eighteenth, which is now conducting its investigations, is the first one to pay much attention to the impact of taxation upon manufacturing. For the first time, it is studying comparative tax burdens in terms of individual manufacturing establishments. I think that its findings will be highly significant and will provide a basis for the legislature to modify existing legislation as needed, to make Massachusetts more attractive to present and prospective manufacturers.

The State of New Hampshire has also initiated a rather intensive study of the environment which it offers to manufacturing concerns. Considerable attention is being given to taxation. Rhode Island, the third state in which tax complaints are outstanding, has also recently awakened to the nature of its problem and is currently trying to find the answer.

Cost of transportation is the second most frequently cited disadvantage. There is little that we can do about our distance from sources of raw materials and markets, but we can adapt our manufacturing processes to the materials most readily available and to the markets most economically reached. The most outstanding example of New England's attempt to better its position with respect to these location factors is the promotion of an integrated New England steel mill, to provide flat-rolled steel products to local metal-working producers at considerably lower prices than are presently paid for steel coming in from outside the region. Such a mill would permit many of the metal fabricators to remain here and expand their business, where otherwise it might prove necessary for them to transfer their operations to another part of the country, in order to remain competitive. This is the real significance of the steel-mill movement, not just the addition of 4,000 or 5,000 jobs in the steel mill itself. Ten times that number of jobs are at stake in the fabricating plants.

Cost of electric power is another item cited by a large number of manufacturers as a competitive disadvantage. It is true that power costs usually amount to only 1 to 2% of total manufacturing costs and that small differentials will not seriously handicap most concerns. Nevertheless, it is a cost item very important to some producers, and any general reduction in power rates would improve the region's competitive position as a whole. Many private utilities are doing what they can to lower power costs, by installing new and more efficient generating and distribution equipment. Some persons are approaching the problem by working for increased public power in New England, either through the greater use of New England's own hydro-electric power potentialities or through exploitation of the St. Lawrence and Passamaquoddy possibilities. I shall not today take sides in the private power vs. public power controversy.

Cost of fuel is another of our important disadvantages. One approach to that problem is the plan to introduce natural gas to most major New England cities during the next few years. This and other similar actions to reduce the cost of transporting fuels from their underground sources to New England can *reduce* the cost differentials between this region and other parts of the country. I suspect, however, that until atomic energy becomes commercially feasible as a source of power and heat, we can never bring those cost differentials to a point where they are no longer important.

I shall skip over a few of the other disadvantages, where there is also ameliorative action underway, and just say a few words about the problem of plant buildings. New England has become increasingly aware in the last two or three years that floor space in itself is not enough. It must offer modern factory buildings, if it is to compete with other areas. The industrial foundation device, where private financial assistance in a community aids existing or new manufacturers to obtain modern factory buildings, has become recognized as an extremely useful device in solving the plant problem. It can take advantage of the favorable community attitude towards manufacturing which is prevalent throughout New England. It has been tried on a small scale in a few New England towns. Many more are currently expressing interest or organizing their efforts.

Another recent approach, which is quite different, is the establish-

ment of the Maine Development Credit Corp. by a Maine banking group. It will be able to provide working capital and, to some extent, equity capital for new and expanding manufacturing enterprises in Maine. It has been set up only within the last few months and has generated tremendous interest throughout the rest of the country.

I could go on and cite numerous additional approaches to the plant-building problem and to many other of New England's problems. The important thing, however, is that they are being recognized and tackled all over New England, and that the action cannot help but improve the competitive position of our manufacturing economy. How great the progress will be depends on the wisdom, coöperation and energy of all New Englanders.

WICKHAM HILL STORAGE RESERVOIRS

A Variation in the Design of Distribution Storage Facilities

BY WILLIAM DORENBAUM*

[*Read March 16, 1950.*]

Prior to 1934, the town of East Hartford was entirely dependent for its water supply on three extremely small reservoirs, with a very large watershed area but a total storage of only 25 mil gal, so that the safe, or dependable, yield was not over 1.5 mgd. These reservoirs are located in the town of Glastonbury, at a very considerable distance from East Hartford, and connected to the distribution system of long lengths of small, unlined, cast-iron pipe lines—principally 4 in. and 6 in. in diameter—by extremely long and old lines, no larger than 16-inch diameter, which are also unlined cast-iron pipes. By 1934 the population had grown to about 20,000; the average consumption had increased to 2.75 mgd, and conditions were serious, as evidenced by insufficient water, inadequate pressure and reduced flows in many locations. That year the town paid for a 10-inch steel pipe line across the Bulkeley Memorial Bridge connecting the Hartford system to the East Hartford lines through a specially designed regulating valve for automatically supplying make-up water to East Hartford, either in small quantities to keep up pressure or in larger quantities up to 1.5 mgd at times of drought, low reservoir stage or extra heavy draft. The population, as well as consumption, continued to grow and conditions grew steadily worse. Finally, negotiations were started for their joining The Metropolitan District of Hartford County. After several years of study and planning, negotiations, etc., East Hartford became a member town of the District in January, 1941, by which time the consumption had increased to 3.75 mgd—considerably more than the safe yield of their reservoirs plus the 1.5 mgd available through the 10-inch steel line across the bridge.

The Water Bureau of The Metropolitan District immediately started a rehabilitation program for the entire system, a program

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which took several years of work and cost about $500,000. The first work consisted of installing two 16-inch cast-iron pipes (temporary lines), one on each sidewalk of the bridge, connecting these by means of a long, 20-inch concrete line to the distribution system at the center of the town and extending the system to the east by some 12-inch and 16-inch cast-iron lines; at the northerly end of the town, several 12-inch and 16-inch cast-iron pipe lines were built. A pressure-regulating system was installed, to permit the Hartford and East Hartford systems to work together, since the East Hartford reservoirs are 50 to 100 ft lower than the West Hartford filtered-water basins—the distributing point for all filtered water. This system consisted of several pressure-regulating valves, located at strategic points. In 1943 all services in the town were metered with the result that use and waste were reduced, and pressures and delivery conditions were improved. In 1944, the pressure-regulating system was revamped by the addition of several other valves and by moving some of those originally installed, and pressures were thereby further improved.

In 1945, the two temporary bridge lines were replaced by one 10-inch steel line under the road and one 16-inch cast-iron line under the south sidewalk, and during the following few years additional 12-inch and 16-inch cast-iron lines were installed in the critical locations. Thus the supply was continually increased and the area served was extended. In 1948, a half-mile of 16-inch and 24-inch cast-iron pipe line was built to the site for the Wickham Hill storage reservoirs. This site was acquired in 1945 for just that purpose. It consists of a large parcel of land in the northeast corner of the town, the highest ground in the town and the only ground sufficiently elevated to be suitable for underground storage. The accompanying map (Fig. 1) shows the relative locations of the major structures and principal transmission mains and pipe lines.

During the year 1949, the consumption of East Hartford averaged 6.0 mgd, of which 3.4 mgd were used by the Pratt and Whitney Aircraft plant, the largest single water consumer in the District. The 6.0 mgd consisted of 4.7 mgd of filtered water from Hartford and 1.3 mgd of chlorinated water from the East Hartford reservoirs. The town now has a population of about 32,000, of which about 25,000 use District water. It is, therefore, obvious that the storage reservoirs

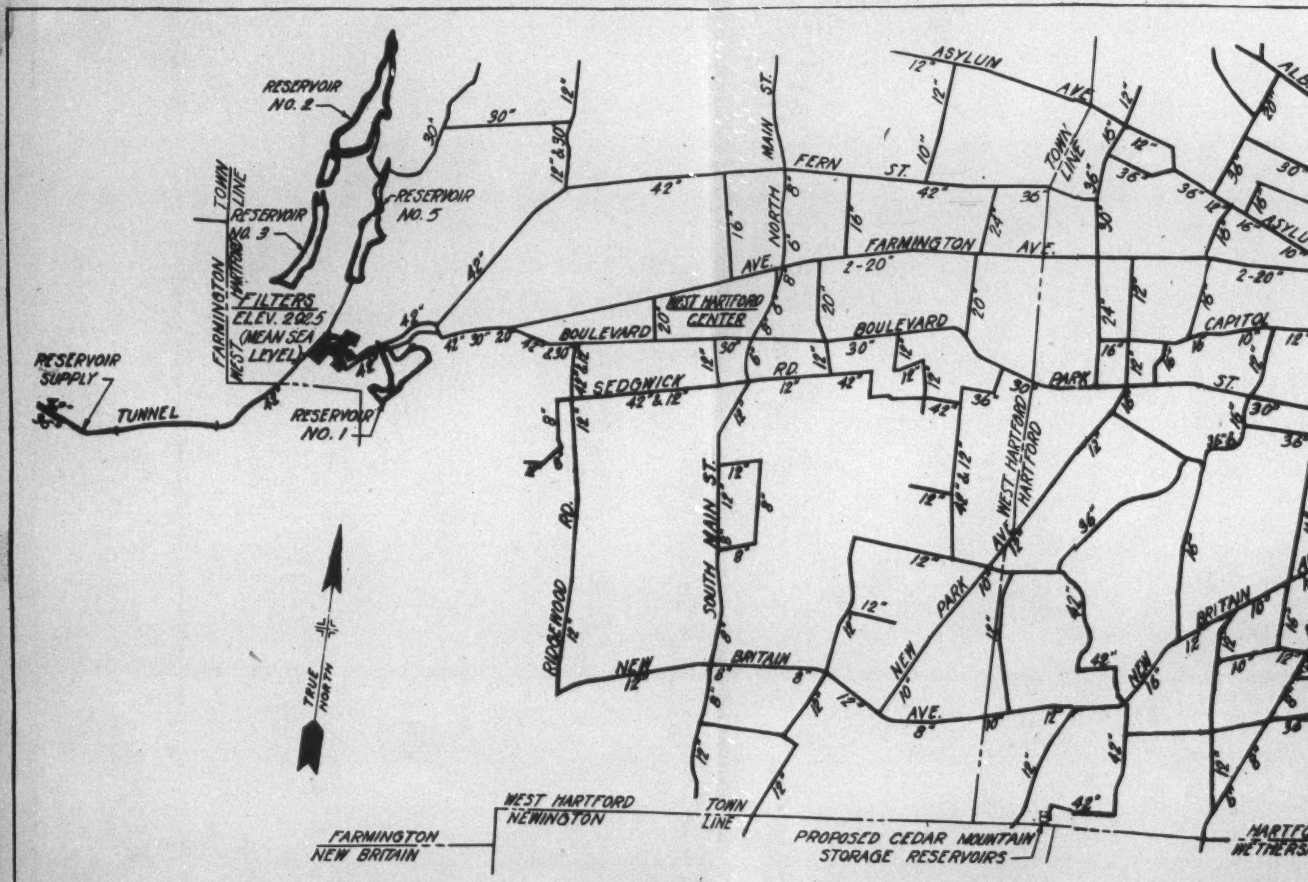
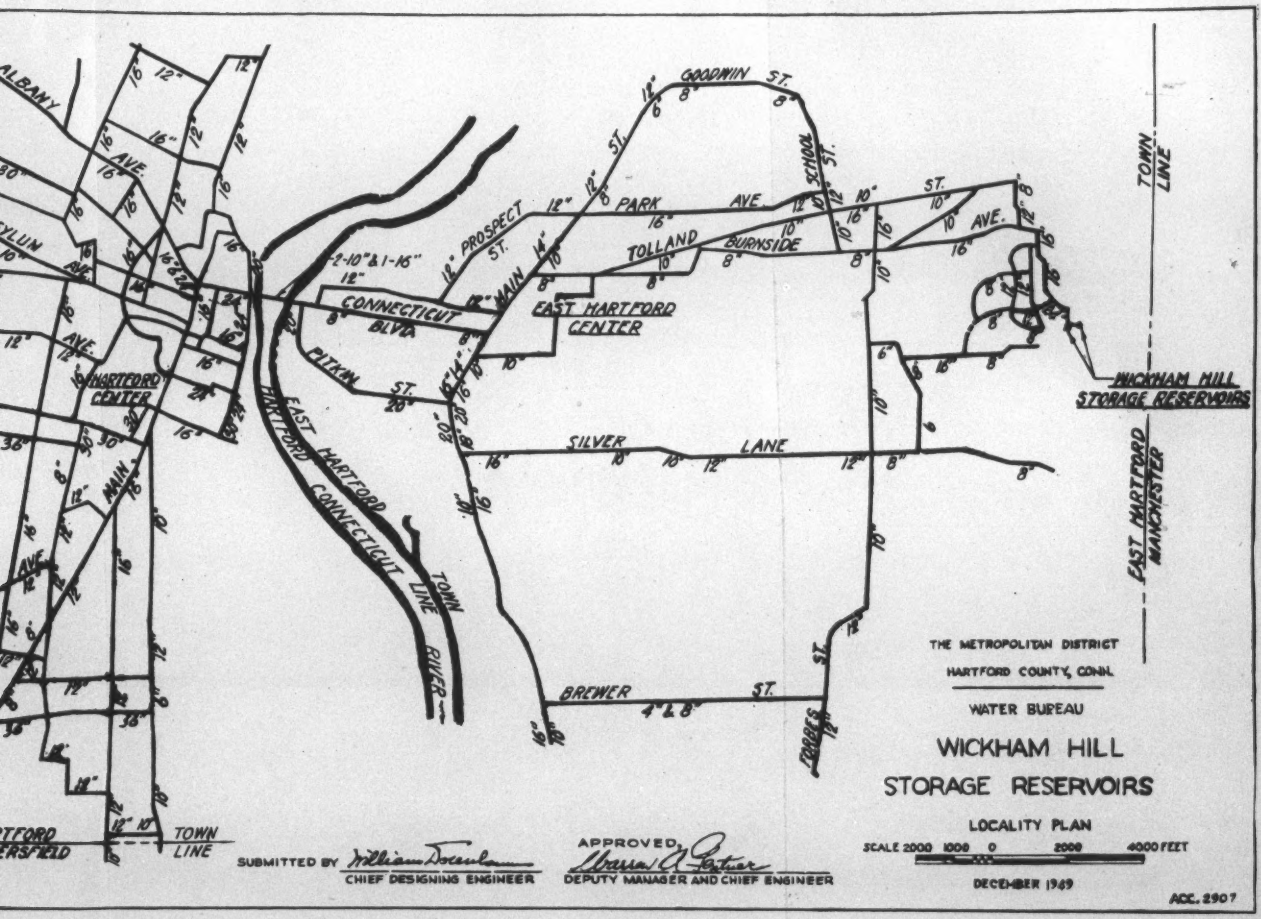

RESERVOIR NO. 2
RESERVOIR NO. 5
RESERVOIR NO. 3
FILTERS ELEV. 282.5 (MEAN SEA LEVEL)
RESERVOIR NO. 1
RESERVOIR SUPPLY
TUNNEL
FARMINGTON WEST HARTFORD TOWN LINE
MAIN ST.
NORTH MAIN ST.
SOUTH MAIN ST.
FERN ST.
ASYLUN AVE.
TOWN LINE
FARMINGTON AVE.
WEST HARTFORD CENTER
BOULEVARD
CAPITOL
PARK ST.
SEDGWICK RD.
RIDGEWOOD RD.
WEST HARTFORD HARTFORD AV.
NEW BRITAIN AVE.
TRUE NORTH
WEST HARTFORD NEWINGTON TOWN LINE
FARMINGTON NEW BRITAIN
PROPOSED CEDAR MOUNTAIN STORAGE RESERVOIRS

FIG. 1.



THE METROPOLITAN DISTRICT
HARTFORD COUNTY, CONN.

WATER BUREAU

WICKHAM HILL STORAGE RESERVOIRS

LOCALITY PLAN

SCALE 2000 1000 0 2000 4000 FEET

DECEMBER 1949

ACC. 2907

SUBMITTED BY William Doremus
CHIEF DESIGNING ENGINEER

APPROVED, Warren A. Fortner
DEPUTY MANAGER AND CHIEF ENGINEER

1.

under construction now will be very important and useful in properly serving East Hartford. At some future time it is expected that the entire town will be served with filtered water and the East Hartford reservoirs held in reserve, as are the old West Hartford reservoirs, for emergency use only. Then these Wickham Hill storage reservoirs will be even more valuable.

The study of the problem of the need for storage in the distribution system generally resulted in the decision to include 4½ mil gal of underground storage, in the town of East Hartford, which at that time was the equivalent of approximately one day's supply for the town. Preliminary studies for the optimum vertical location for this storage indicated the need for a range of at least 50 ft, the bottom to be set at such an elevation as would provide a reasonable amount of emergency storage and the top at the highest possible elevation, to provide the greatest improvement in pressures and extend gravity service to higher areas, under conditions of sustained minimum draft. The bottom elevation was set tentatively at elevation 232.5, resulting in the top at elevation 282.5, referred to mean sea level. However, further study of drafts and their frequency of occurrence during 1946, and their effect on maintaining tentative reservoir elevations, showed that District drafts of 19 to 23 mgd would tend to overflow between elevations 282.5 and 277.5—these drafts occurring about 27 days during 1946. It was apparent that the top 5 ft of this storage would be useful for less than one month during the year and, consequently, very expensive. Therefore, the decision was to build 45 ft of storage, and the hydraulic studies were summarized and reduced to diagrammatic form as shown on the accompanying chart (Fig. 2), which, in brief, shows the relation between daily drafts, occurrence during the year and the corresponding reservoir elevations. The reservoir elevations were plotted against drafts, showing upper and lower limits, drawn on the basis of 100,000 gal per foot of depth of storage capacity. Plotted also were the 1946 upper and lower limits of reservoir elevations corresponding to time, the basis being the number of days occurrence of the various drafts in 2-mgd increments. It is apparent from these curves that, with the normal growth in consumption and the tendency for the maximum to increase, the top elevation of usefulness is naturally lowered and, consequently, the overflow level

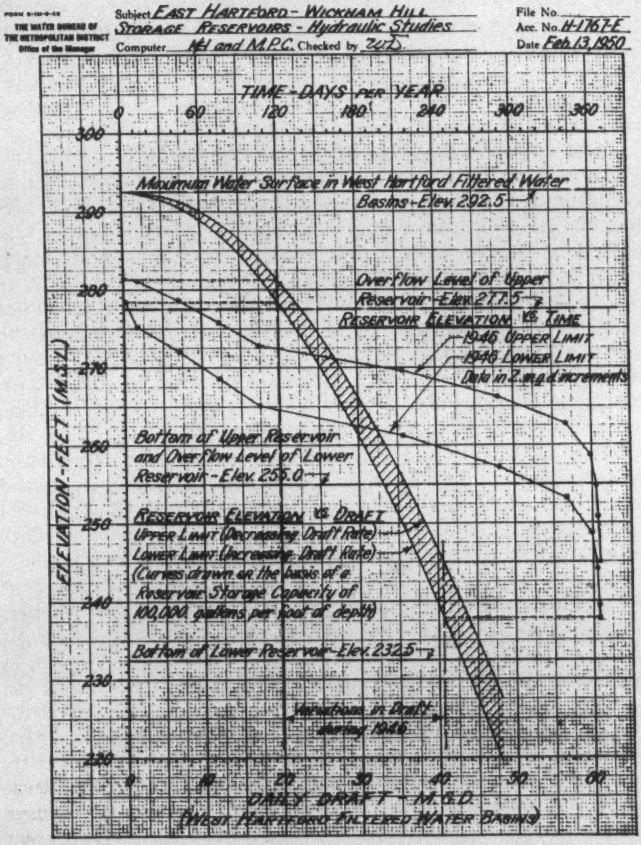

FORM 9-1M-9-48
THE WATER BUREAU OF THE METROPOLITAN DISTRICT
Office of the Manager
Subject EAST HARTFORD - WICKHAM HILL STORAGE RESERVOIRS - Hydraulic Studies
Computer H-1 and M.P.C. Checked by ZUD.
File No.
Acc. No. H-1767-E
Date Feb. 13, 1950
TIME - DAYS PER YEAR
0
60
120
180
240
300
360
300
290
280
270
260
250
240
230
220
ELEVATION - FEET (M.S.L.)
Maximum Water Surface in West Hartford Filtered Water Basins - Elev. 292.5
Overflow Level of Upper Reservoir - Elev. 277.5
RESERVOIR ELEVATION VS TIME
1946 UPPER LIMIT
1946 LOWER LIMIT
Data in 2 m.g.d. increments
Bottom of Upper Reservoir and Overflow Level of Lower Reservoir - Elev. 255.0
RESERVOIR ELEVATION VS DRAFT
UPPER LIMIT (Decreasing Draft Rate)
LOWER LIMIT (Increasing Draft Rate)
(Curves drawn on the basis of a Reservoir Storage Capacity of 100,000 gallons per foot of depth)
Bottom of Lower Reservoir - Elev. 232.5
Variations in Draft during 1946
0
10
20
30
40
50
60
DAILY DRAFT - M.G.D.
(WEST HARTFORD FILTERED WATER BASINS)

FIG. 2.

was definitely set at elevation 277.5 (no overflow for 23-mgd draft), with the result that the bottom was fixed at elevation 232.5. With the quantity fixed at 4½ mil gal and the vertical locations set at the 45-foot range between elevations 232.5 and 277.5, the next step was the consideration of type of structure, because of the realization that a more-than-normal depth for underground storage was involved.

The following basic facts relative to the hydraulic studies as diagrammed on the accompanying chart may be found of interest and value. The upper and lower limits of storage on the basis of daily drafts were determined from the actual distribution of rates for the minimum daily draft of 20.5 mil gal on April 9, 1944, for the maximum daily draft of 36.7 mil gal on July 10, 1944, and for an expected "near future" maximum of 45 mgd distributed proportionately to the actual maximum-day drafts, with about 16% for East Hartford. Incidentally, on June 21, 1949, due to extremely dry and hot weather and need for considerable sprinkling and irrigation of crops, a maximum draft of filtered water of 43.5 mgd was recorded, which would have theoretically emptied the reservoir.

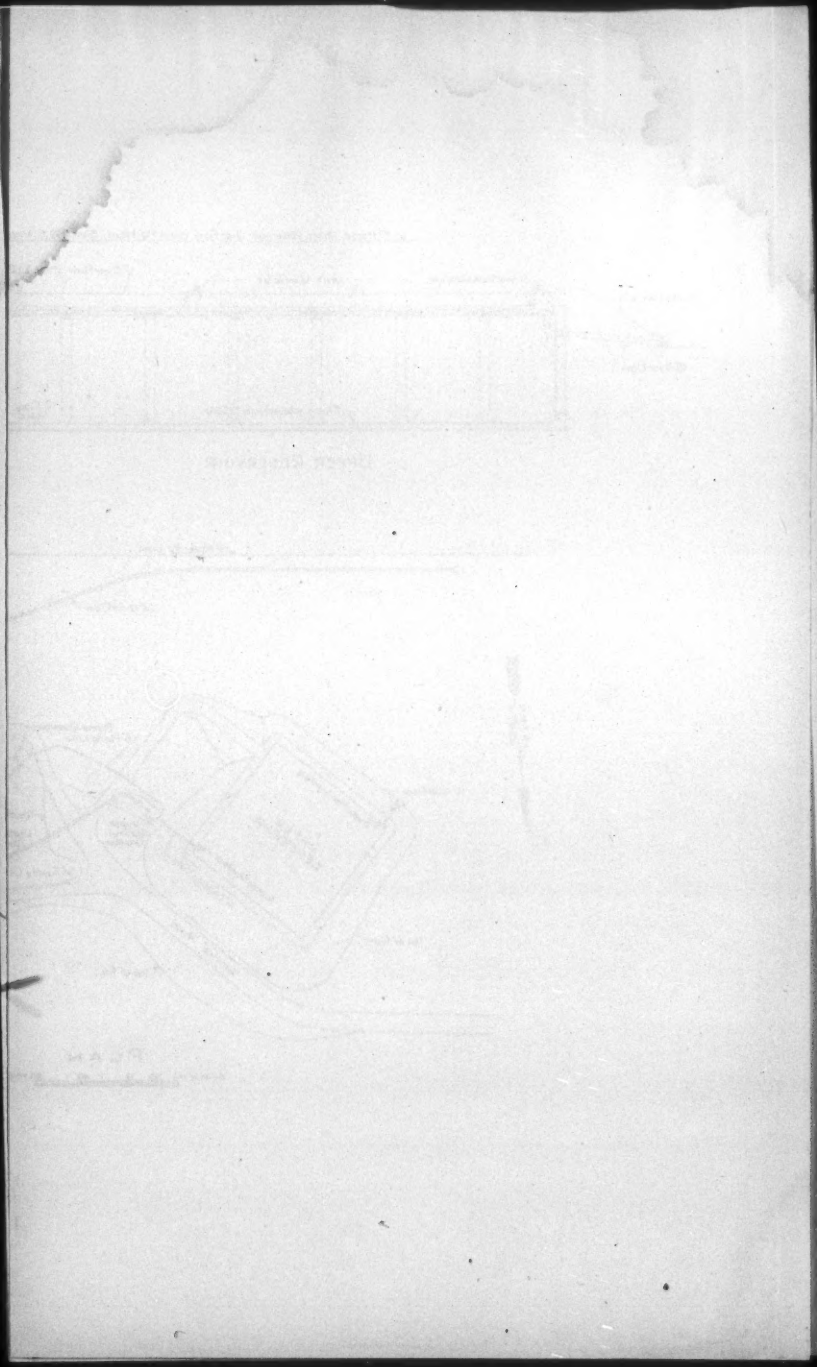
It is evident from the curves that normally a very substantial, emergency reserve storage would be available, which the normal growth in demand would lower. However, normal transmission-main and distribution-pipe-line improvements in step with draft increases would maintain the storage reservoir in fully operative condition, as was contemplated in the studies and basic design. This chart shows the variations in draft during 1946, when the range was 19.9 to 40.6 mgd and the records show rates of draft ranging from about 11 to 55 mgd of filtered water. East Hartford's share of about 16% was supplemented with about 1 to 2 mgd of chlorinated water from their original reservoirs. To simplify the complex computations, due to the several variable factors in the problem, the water surface in the filtered-water basins was assumed at elevation 292.5 (overflow level). Naturally, the use of such curves for practical purposes must take into account the actual condition of the filtered-water basins for the period under consideration. With the completion of the proposed 10 mil gal storage at the Cedar Mountain site in Hartford, for which the excavation and foundation work are now underway, and with the additional filter beds to be built in the very near future, the trend will be to iron

out the extreme ranges in rates of draft and towards a more uniform rate of filtering and more uniformly full filtered-water basins, with consequent improvement in the operation of the Wickham Hill storage reservoirs.

The 1946 upper- and lower-limit curves of reservoir elevation vs. time were based on the plotted points of recorded daily drafts, taken in 2-mgd increments. These show that the reservoirs would be in use as follows:—the upper reservoir alone about 10 months, the two reservoirs together less than 2 months and the lower one alone about 1 week. However, it may be inferred from the curves that, with the increase in draft, similar curves would tend to lower in the diagram, decreasing the time of use of the upper reservoir alone and increasing the use of the lower reservoir alone. It is believed, therefore, that the reservoirs actually will be in use as follows:—the upper reservoir alone about 9 months, the two reservoirs together about 2½ months, and the lower reservoir alone about ½ month. Any extensive improvements in the transmission- and distribution-piping systems, as delineated in part on the accompanying map, will vary the relative time periods as outlined. To have set the bottom of the reservoir any lower would have been an added expense not justified, because of the difficulty in drawing water into the system at that range, and would be of use only in very rare and unusual conditions in the system.

It seemed very clear that one 45-foot reservoir would be very expensive and difficult to build and maintain. To keep a reservoir watertight with a 22½-foot head is difficult enough, but one with 45-foot head would require much heavier walls and would be extremely difficult to repair in case leaks did develop. Foundation loads would be heavier than is desirable on an earth foundation, such as found at Wickham Hill site. Also, the appearance of such a high structure was considered objectionable. The selected set-up of two equal-size reservoirs, each of 2¼-mil gal storage, lends itself automatically to easy periodic access to the interiors for inspection, cleaning and repair purposes, without affecting pressures and flows in the East Hartford distribution system, because of the wide range of normal elevation fluctuations, as shown on the diagrams previously mentioned.

Now the problem of selecting the most economical location for the two reservoirs on the District land was tackled. About 24 test pits



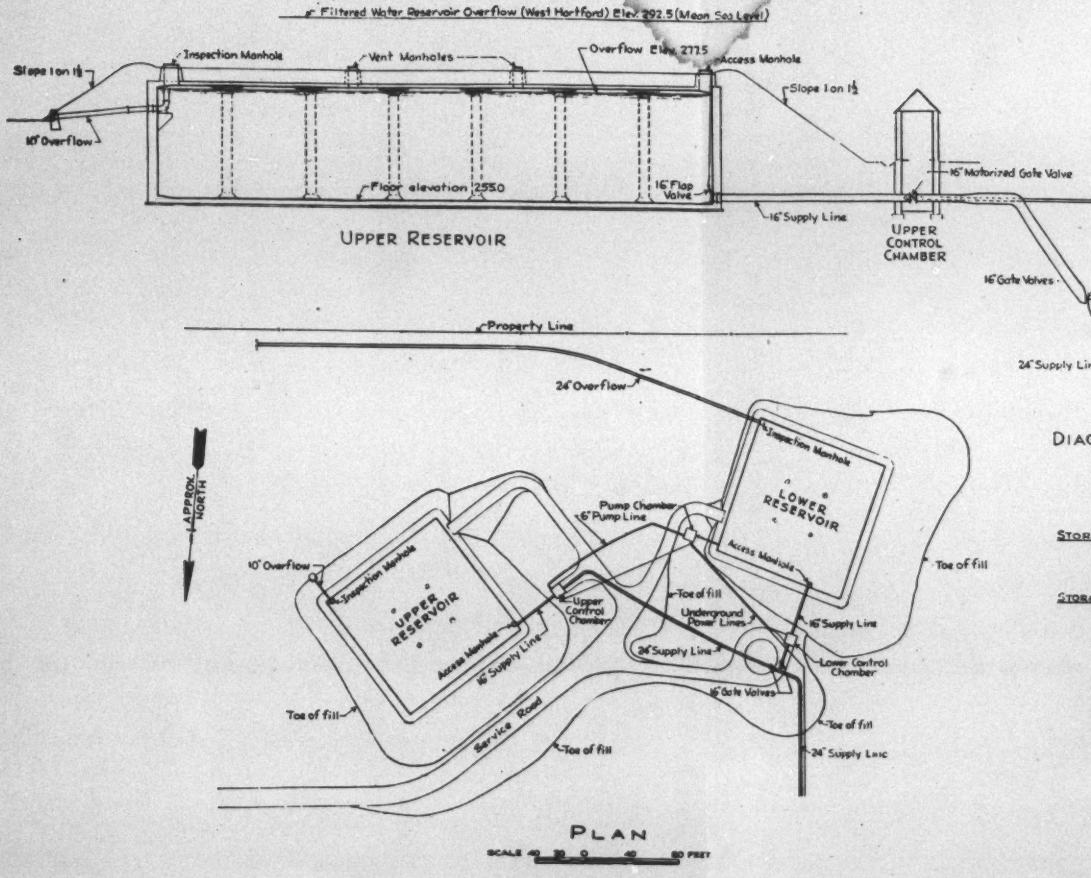
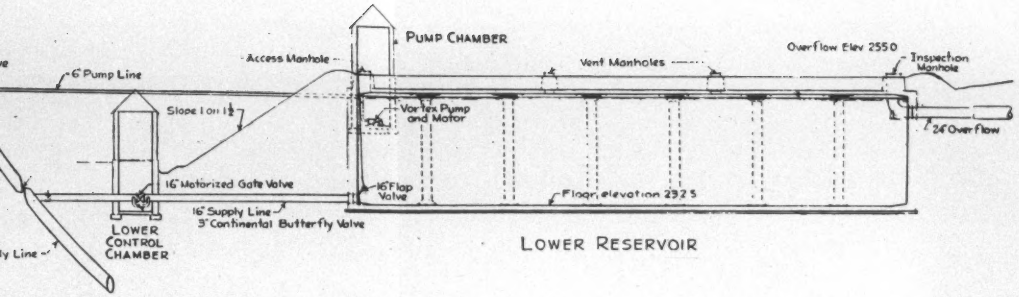

8" Filtered Water Reservoir Overflow (West Hartford) Elev. 292.5 (Mean Sea Level)
Slope 1 on 1½
Inspection Manhole
Vent Manholes
Overflow Elev. 277.5
Access Manhole
Slope 1 on 1½
16" Overflow
Floor elevation 255.0
16" Flap Valve
16" Motorized Gate Valve
16" Supply Line
UPPER RESERVOIR
UPPER CONTROL CHAMBER
16" Gate Valves
Property Line
24" Overflow
APPROX. NORTH
Inspection Manhole
LOWER RESERVOIR
Pump Chamber
16" Pump Line
Access Manhole
Toe of fill
10" Overflow
Inspection Manhole
UPPER RESERVOIR
Upper Control Chamber
Toe of fill
Underground Power Lines
16" Supply Line
Access Manhole
16" Supply Line
24" Supply Line
Lower Control Chamber
16" Gate Valves
Toe of fill
Service Road
Toe of fill
24" Supply Line
Toe of fill
PLAN
SCALE 40 20 0 40 80 FEET

FIG. 3



IAGRAMMATIC CROSS SECTION

SCALE 10 5 0 10 20 FEET

STORAGE RESERVOIRS - GENERAL DATA

117 feet square, inside
23 feet 3 inches deep, inside
22 feet 6 inches maximum water depth (at overflow level)
2½ million gallons capacity, each of two reservoirs

STORAGE RESERVOIRS - STRUCTURAL DATA

Roof - Reinforced Concrete
9½" thick, "flat-slab" construction
2'-9" earth cover
Maximum live load - 1 Ford "Pick-up"
Walls - Reinforced Concrete
24" thick, "rigid frame" construction
Will carry earth and/or water load
Floor - Reinforced Concrete
13½" thick, "flat-slab" construction to spread wall, column, and water loads evenly on earth foundation to stay within building code requirements.
Sub-floor - Plain concrete
4" thick
to provide surface for membrane waterproofing
Columns - Reinforced concrete
24" diameter
36 in each reservoir

CONTROL CHAMBERS

7 feet square inside
Contain motorized valves, recording gages, and automatic control equipment to prevent reservoir overflow.

PUMP CHAMBER

7 feet square inside
Contains 150 gallon per minute (about 200,000 gallons per day) centrifugal pump to:
1.) Keep Lower Reservoir water fresh when Upper Reservoir is in use
2.) Fill Upper Reservoir for emergency storage when Lower Reservoir is in use.

RESERVOIR OPERATION

Upper Reservoir only - about 9 months
Lower Reservoir only - about ½ month
Both Reservoirs simultaneously - about 2½ months

THE METROPOLITAN DISTRICT
HARTFORD COUNTY, CONN.

WATER BUREAU

WICKHAM HILL STORAGE RESERVOIRS

GENERAL ARRANGEMENT

SCALES AS INDICATED

JUNE 1949

SUBMITTED BY William Doran
CHIEF DESIGNING ENGINEER

APPROVED Thomas N. Parker
DEPUTY MANAGER AND CHIEF ENGINEER

G. 3.

were dug, to determine the soil-classification and foundation conditions which would influence the structural design. Since neither rock nor ground water were encountered, the matter of location was reduced to the simple task of computing the comparative costs in various locations, together with consideration of the desirability of keeping the two reservoirs well separated, for safety's sake. The location finally selected was one where the cuts and fills of the earthwork balanced, with the two reservoirs spaced about 200 ft apart, located on a hardpan foundation of a fairly uniform nature. A brief, general description of the reservoirs follows.

As may be noted in complete detail on the accompanying drawing (Fig. 3), the storage reservoirs consist of two similar earth-covered, reinforced-concrete structures, each 117.0 ft square and 23.25 ft deep, inside dimensions. Each has a capacity of 2¼ mil gal at overflow level (22.5 ft maximum depth of water), making a total capacity of 4½ mil gal, with an overall total depth of water of 45.0 ft, the overflow of the lower reservoir being at the same level as the floor of the upper reservoir.

The reservoir structures are of higher-strength concrete than has usually been specified by The Water Bureau in the past. This is partially to reduce the amount of concrete required, but its primary purpose is to secure a high-quality, dense concrete, that will be as nearly watertight as is practicable to obtain. Leakage is further reduced by installing copper water-stops, "pleated" to allow expansion and contraction in all construction joints, and by specifying an order of sequence for pouring the concrete sections, to reduce the construction-joint openings due to the initial shrinkage of newly-poured concrete.

The roofs are 9½-in. thick, of so-called "flat-slab" construction, reinforced two ways, to carry 2.75 ft of earth, which is used primarily as insulation, and capable of carrying also the load of a "pick-up" truck, the unit normally used for inspection and light maintenance operations. The walls are 24 in. thick, reinforced to carry earth loads, water loads, or both simultaneously. This thickness is deliberately somewhat greater than structural conditions require, in order to reduce, if not eliminate entirely, leakage through the walls. The columns are 24 in. in diameter, normally spaced 17.5 ft center to center, reinforced

to carry the roof loads. The floors are 13½ in. thick, of flat-slab construction, reinforced two ways, to distribute wall, column and water loads uniformly over the earth foundation and thus keep foundation loads within the requirements of the East Hartford building code. The various component parts—floor, wall, column and roof—were considered together as a rigid frame in the design analyses, to effect a structure of ample strength with reasonable factors of safety.

Since the earth foundation material contains clay and may thus become soft, if allowed to become water-soaked, a heavy membrane waterproofing is required between a 4-inch plain concrete sub-floor, laid directly on the hardpan foundation, and the structural, reinforced-concrete floor slab, to prevent leakage directly into the foundation. As a supplementary protection, a tile-and-gravel base drain is placed at foundation level all around each reservoir. This drain serves to collect ground water or any seepage through the reservoir walls, and conduct it away from the foundation. Surface water from the tops of the reservoirs is collected and dropped through riser pipes into these base drains for rapid disposal. Cast-iron drains, controlled by gate valves, are located in each corner of both reservoirs, to permit emptying reservoirs for inspection, cleaning or repairs, and discharge into this same drainage system, access to which is available through deep manholes, built at each corner of both reservoirs.

As has been previously stated, the overflow of the lower reservoir is at the same level as the floor of the upper reservoir and, since each reservoir has a maximum water depth of 22.5 ft, the result is the equivalent of 45.0 ft of storage for normal operation purposes of improving pressure and flow conditions and providing also some emergency storage. The higher overflow is set at 15.0 ft below the overflows of the filtered-water basins at the West Hartford filtration plant. This vertical range was selected as a result of very extensive pressure and flow studies of the hydraulics of the major and principal portions of the distribution system from the filters to the Wickham Hill reservoir site. The following major conclusions are emphasized:—

(1) on only infrequent and low-consumption days will it be possible to fill the upper reservoir higher than the overflow level;

(2) on only infrequent and high-consumption days will the upper reservoir be empty and the lower reservoir nearly so;

(3) in the course of normal variations in consumption, reservoir levels will vary from a narrow daily range in the upper portion of the upper reservoir during the winter, through a widening band in the upper reservoir during the spring and fall, to a band including the lower third of the upper reservoir and the upper two-thirds of the lower reservoir during the summer.

To offset the tendency for the lower reservoir to overflow much of the time and the upper reservoir occasionally, automatic controls are to be provided, to shut off reservoir inflow at the proper and necessary times. This is to be accomplished by the installation of a motorized gate valve in the supply main to each reservoir. These motorized gate valves are to be automatically controlled by sensitive pressure switches, which will cause the proper valve to close when a reservoir is full and to open when the line pressure drops to a predetermined value. Should electric power be temporarily interrupted or should the electrical devices fail to function, overflow pipe lines have been provided, which are capable of carrying all the water which can enter the reservoirs above their capacities. These overflow lines will discharge on District land into a drainage channel, running through adjoining private property, and thence through a large culvert under the Wilbur Cross Highway. Drainage rights for this purpose were obtained from the property owner and the State Highway Department.

From the same gage lines that are to transmit reservoir pressure to the pressure switches for automatic control purposes, pressure will be supplied to automatic water-level recorders. To obtain the desired accuracy, without making the foundations of the control houses too deep and expensive, a mercury-operated gage with float type of recorder was specially designed by the Builders-Providence, Inc. These recorders are to be located in the control houses with the motorized gate valves and the automatic control equipment. Thus all control and recording equipment will be kept easily accessible, and checking and adjustments will be facilitated. These control houses are small brick chambers on plain concrete foundations and are 7.0 ft square inside. Insulation is provided so that a small amount of electricity will protect the pipe lines, valves, etc., against freezing during the winter months.

As the hydraulic studies progressed, it became apparent that the lower reservoir would remain full of water without circulation for

extended periods of time. This raised the question as to the effect of this stagnation on water quality. Extended model tests, which were run at the West Hartford filtration plant, simulating the concrete reservoir and its operation, showed that the pH and alkalinity increased very rapidly. Thus, when finally released, such water might adversely affect its use for certain industrial purposes and, under certain conditions, might result in delivery of "red water" to consumers. The experiments showed further that, by painting the concrete with the same asphalt enamel that is currently used for seal-coating the cement lining of cast-iron pipes, the rate of increase in pH and alkalinity was tremendously decreased, to a point where the change in two weeks was slight. However, the pH and alkalinity did increase in several months to undesirable limits.

For this reason, two coats of asphalt paint are required to be applied on all concrete surfaces exposed to contact with reservoir water, and provision has been made for a circulating pump capable of pumping all the lower reservoir water into the upper reservoir in about 10 days. It is planned to run this pump continuously, during the period the lower reservoir is not in normal operation, and thus to change about 10% of the lower reservoir water each day. To avoid wear and tear on the main motorized gate valve, and to eliminate the danger of losing a large quantity of water, should electric power fail while the lower reservoir is being refilled each day, a 3-inch, motorized butterfly valve has been set up as a by-pass around the 16-inch gate valve and connected in with the reservoir pressure switch, in such a way that the circulation of lower reservoir water is handled by the smaller valve automatically and safely.

In the event that the water level in the lower reservoir should become lowered too close to the pumping-line intake, the pump is protected against continued operation for too long by automatic controls, by means of an electrically operated float switch. This pumping layout makes it possible also to provide additional emergency storage. During periods of extremely high summer drafts, by closing the upper reservoir control-valve manually and pumping the reservoir full of water from the lower reservoir, 2¼ mil gal of emergency storage are made ready and available for fighting a major fire or for any other need which may arise. Pump and controls are to be located in a

chamber similar in size and character to the control houses. Space is available in the pump house for a generator set for stand-by electric service, should experience ever indicate its desirability.

Electricity will be provided for lights and heaters in the control chambers and pump chamber, for the circulating pump motor, for control of the two gate-valve motors and for control of the butterfly-valve motor through an underground power line, consisting of 4 cables (230-volt, 3-phase, 60-cycle A.C. current), extending from the Hartford Electric Light Company's overhead line in the public highway, fronting the District land, to the pump-chamber distribution panel, from which there is an underground branch line to each control chamber. There will also be 115-volt circuits available as required. In this way, should electric-power interruptions prove frequent or troublesome, a generator set could be installed with suitable cut-outs, so that stand-by service could be thrown on the line automatically.

In addition to the major structures described, there are the usual lines for transmitting water and drainage, overflow pipe lines and a service road, extending from the public highway to each of the buildings, and a connecting ramp drive to the top of each reservoir, all graded to harmonize with the adjoining areas and provided with proper drainage facilities.

By the end of January of this year, the lower reservoir was completed sufficiently to run the required leakage tests. The reservoir was filled to overflow level and measurements were then taken every 24 hours, to determine the loss of water from storage. At the end of 3 days the measurements showed a maximum loss of 4,200 gal in 24 hours, compared with the specified allowable leakage of not more than 6,000 gal. At the end of 10 days of measurements the leakage was reduced to 2,100 gal in 24 hours. It is believed that, with the completion of the required painting of the interior concrete surfaces, this leakage might be further reduced considerably, to indicate a practically watertight structure. After painting, the reservoir will be refilled and properly sterilized. Then the reservoir will be ready to be put into operation for regular use.

This project is a part of the water-supply system of The Metropolitan District of Hartford County, of which Edward N. Allen is Chairman of the District Commission. E. Welles Eddy is Chairman

of The Water Bureau, under whose authority the Wickham Hill storage reservoirs were designed and are now under construction.

All of the functions of The Metropolitan District are under the management of William A. D. Wurts, District Manager, and The Water Bureau is managed by Warren A. Gentner, Deputy Manager and Chief Engineer, with C. M. Saville as Consulting Engineer.

The construction work is being carried on by the American Construction Co. of Hartford, Conn., and will probably be completed by June of this year. The cost of the construction, materials furnished by the District, soil and foundation investigations, land, drainage rights, building permit and engineering will aggregate about $375,000. An innovation initiated with this project was the furnishing to the contractor of all the principal materials except concrete, to avoid delays and interruptions during construction. Designs were completed and materials listed far enough ahead so that they would all be on hand in sufficient time for installation on schedule. This experiment has proved highly successful, since there have been no delays and no interruptions, and the District has had better control over the specifications and quality of the materials. Incidentally, the District has saved about $25,000.

DEPTH DETERMINATIONS FROM SEISMIC DATA

BY ROBERT L. GEYER*

[*Received August 31, 1950.*]

LINEHAN AND KEITH** have described use of the refraction seismograph for determining the nature and thicknesses of near-surface layers in New England. In their paper they cite a well-known relation for the determination of the thicknesses of the several layers, in terms of the coördinates of the intersections of their corresponding branches on the travel-time curve. While that form is accurate and comparatively simple to use, there is another form, used in seismic prospecting for computing the thicknesses of the near-surface, low-velocity layers, that is accurate within the limits of field observations and adaptable to rapid slide-rule computation. This alternate method utilizes the time-axis intercepts of the extrapolated branches of the travel-time curve.

Fig. 1 presents a hypothetical geologic section of several horizontal strata, above which is drawn a travel-time curve such as might have been determined from arrival times of refracted waves at a series of stations between points S and G. The distance from the shot point S to a seismic receiver (geophone) G is designated d_g, the corresponding arrival time of the refracted wave is designated t_g, and the corresponding point on the travel-time curve is indicated by a small circle. The ray-path of the elastic energy from shot point to geophone is shown by a series of arrows. The layers are numbered from the surface to the basement, which would correspond to layer n+1. The thicknesses of the layers are indicated by the letter h, with the appropriate subscript indentifying the layer.

The velocities of elastic waves in any layer are assumed to be constant and may be obtained from the slope of the corresponding branch of the travel-time curve. The thickness h, which we wish to find, is equal to the product of the velocity V, obtained from the graph,

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**Daniel Linehan, S. J., and Scott Keith. "Seismic Reconnaissance for Ground-Water Development." This Journal, Vol. 63, No. 1 (Mar., 1949), p. 76.

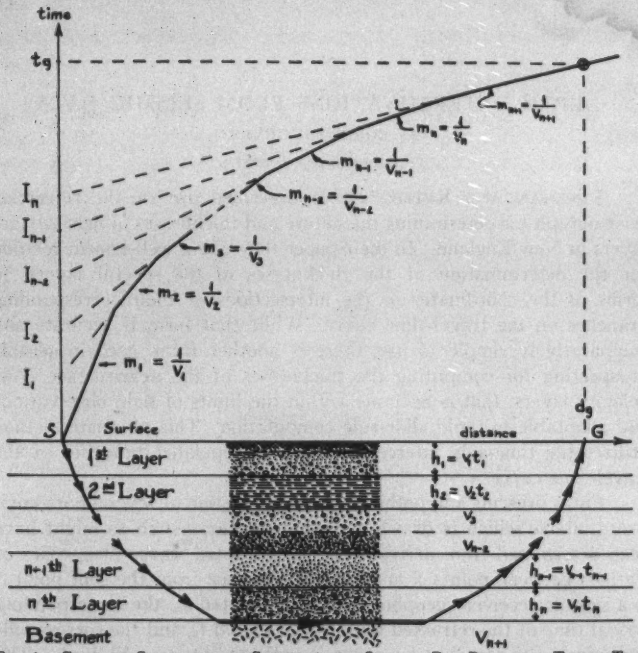

FIG. 1.—GEOLOGIC SECTION WITH SUPERIMPOSED SEISMIC RAY-PATH AND TRAVEL-TIME CURVE.

and the vertical time t, which is a function of the time-axis intercept I and a velocity ratio.

In order to determine the thicknesses of the layers from the seismic records, it is only necessary to follow these simple steps:

(1) Pick the times from the records.

(2) Plot the times versus corresponding geophone distances and draw the time-distance curve.

(3) Determine the velocities and intercepts from the curve and enter them in their places in a computation form, such as shown in Tables 1, 2 and 3.

(4) Calculate the thicknesses for each layer by means of the values and formulae in Table 4; or calculate them by the use of a special K-scale, marked on an engineer's slide rule, and the same formulae.

The entire process should not require more than 15 minutes per spread, if there were no more than three layers involved, and the last step should require only a couple of minutes of that time.

TABLE 1.—CALCULATION FORM FOR ONE LAYER

$V_1 =$ ____ $V_2 =$ ____	$\frac{V_1}{V_2} =$ ____	$I =$ ____	$t_1 =$ ____	$h_1 =$ ____

TABLE 2.—CALCULATION FORM FOR TWO LAYERS

$V_1 =$ ____	$\frac{V_1}{V_2} =$ ____	$I_1 =$ ____	$t_1 =$ ____	$h_1 =$ ____
$V_2 =$ ____	$\frac{V_1}{V_3} =$ ____	$I_2 =$ ____		
$V_3 =$ ____	$\frac{V_2}{V_3} =$ ____	$T_{13} =$ ____	$t_2 =$ ____	$h_2 =$ ____
		$I_2 - T_{13} =$ ____	$\Sigma t =$ ____	$\Sigma h =$ ____

TABLE 3.—CALCULATION FORM FOR THREE LAYERS

$V_1 =$ ____	$\frac{V_1}{V_2} =$ ____	$I_1 =$ ____	$t_1 =$ ____	$h_1 =$ ____
$V_2 =$ ____	$\frac{V_1}{V_3} =$ ____	$I_2 =$ ____		
$V_3 =$ ____	$\frac{V_2}{V_3} =$ ____	$T_{13} =$ ____	$t_2 =$ ____	$h_2 =$ ____
$V_4 =$ ____	$\frac{V_2}{V_4} =$ ____	$I_2 - T_{13} =$ ____		
$\frac{V_1}{V_4} =$ ____	$\frac{V_3}{V_4} =$ ____	$I_3 =$ ____	$t_3 =$ ____	$h_3 =$ ____
$T_{14} =$ ____	$T_{24} =$ ____	$I_3 - (T_{14} + T_{24}) =$ ____	$\Sigma t =$ ____	$\Sigma h =$ ____

TABLE 4.—TABLE OF VELOCITY RATIOS AND CALCULATION CONSTANTS, WITH SLIDE-RULE RELATIONS

$\frac{V_1}{V_j}$	K_{1j}	$\frac{V_1}{V_j}$	K_{1j}	$\frac{V_1}{V_j}$	K_{1j}	$\frac{V_1}{V_j}$	K_{1j}
.10	.503	.30	.524	.50	.576	.70	.699
.12	.504	.32	.528	.52	.584	.72	.720
.14	.505	.34	.531	.54	.593	.74	.743
.16	.506	.36	.535	.56	.608	.76	.767
.18	.508	.38	.540	.58	.613	.78	.797
.20	.511	.40	.545	.60	.624	.80	.833
.22	.513	.42	.551	.62	.637	.82	.872
.24	.515	.44	.557	.64	.650	.84	.921
.26	.518	.46	.563	.66	.665	.86	.978
.28	.521	.48	.569	.68	.682	.88	1.050
						.90	1.145

SLIDE-RULE RELATIONS FROM EQUATIONS 10, 11 AND 12

Layer	T_{1j}	t_1	h_1
1	——	$t_1 = I_1 \times K_{12}$	$h_1 = V_1 \times t_1$
2	$T_{13} = \frac{t_1}{K_{13}}$	$t_2 = K_{23}[I_2 - T_{13}]$	$h_2 = V_2 \times t_2$
3	$T_{14} = \frac{t_1}{K_{14}}$ $T_{24} = \frac{t_2}{K_{24}}$	$t_3 = K_{34}[I_3 - (T_{14} + T_{24})]$	$h_3 = V_3 \times t_3$

The following sections develop the formulae from known relations that are discussed in the several texts on seismology and geophysics, describe more fully the application, note the procedure for the problem of dipping layers, and discuss the accuracy of the system.

THEORY

For a full development of the steps leading to equation 1, the reader is referred to Nettleton,* pages 251-255.

If the notation of Fig. 1 is used, the total travel time from shot point to geophone may be written as

*L. L. Nettleton, *Geophysical Prospecting for Oil*, McGraw-Hill, 1940.

$$t_s = \frac{d_s}{V_{n+1}} + \frac{2h_1}{V_1}\left[1-\left(\frac{V_1}{V_{n+1}}\right)^2\right]^{1/2} + \frac{2h_2}{V_2}\left[1-\left(\frac{V_2}{V_{n+1}}\right)^2\right]^{1/2} + \cdots + \frac{2h_{n-1}}{V_{n-1}}\left[1-\left(\frac{V_{n-1}}{V_{n+1}}\right)^2\right]^{1/2} + \frac{2h_n}{V_n}\left[1-\left(\frac{V_n}{V_{n+1}}\right)^2\right]^{1/2}. \quad (1)$$

For the purpose of simplifying numerical evaluations of our formulae, we let

$$K_{ij} = \frac{1}{2}\left[1-\left(\frac{V_i}{V_j}\right)^2\right]^{-1/2} \quad (2)$$

in which $i<j$, i varies from 1 to n, and j varies from 2 to $n+1$; and

$$t_i = \frac{h_i}{V_i} \quad (3)$$

in which i varies from 1 to n. By incorporating substitutions 2 and 3 in equation 1 we may write

$$t_s = \frac{d_s}{V_{n+1}} + \frac{t_1}{K_{1(n+1)}} + \frac{t_2}{K_{2(n+1)}} + \cdots + \frac{t_{n-1}}{K_{(n-1)(n+1)}} + \frac{t_n}{K_{n(n+1)}}. \quad (4)$$

Since the time-axis intercept represents the travel-time where $d_s = 0$, we have

$$I_n = \frac{t_1}{K_{1(n+1)}} + \frac{t_2}{K_{2(n+1)}} + \cdots + \frac{t_{n-1}}{K_{(n-1)(n+1)}} + \frac{t_n}{K_{n(n+1)}}. \quad (5)$$

For the first layer $n = 1$, and

$$I_1 = \frac{t_1}{K_{12}}. \quad (6)$$

As K_{12} can be computed from equation 2 and I_1 can be obtained from the travel-time graph, t_1 is the only unknown quantity and may be computed from equation 6.

$$t_1 = K_{12}I_1. \quad (7)$$

Similarly, the time in the second layer can be determined from equation 5 as

$$t_2 = K_{23}\left[I_2 - \frac{t_1}{K_{13}}\right]. \quad (8)$$

The time t_1 is known from equation 7, and therefore t_2 can be computed.

The general equation for the time in any layer, expressed in terms of the times in the overlying layers, the intercept, and the velocity-ratio constants K_{ij} is

$$t_n = K_{n(n+1)}\left[I_n - \left(\frac{t_1}{K_{1(n+1)}} + \frac{t_2}{K_{2(n+1)}} + \cdots + \frac{t_{n-2}}{K_{(n-2)(n+1)}} + \frac{t_{n-1}}{K_{(n-1)(n+1)}}\right)\right]. \tag{9}$$

The numerical evaluation may be further simplified by the substitution

$$T_{ij} = \frac{T_i}{K_{ij}}, \tag{10}$$

and equation 9 may be rewritten as

$$t_n = K_{n(n+1)}[I_n - (T_{1(n+1)} + T_{2(n+1)} + \cdots T_{(n-2)(n+1)} + T_{(n-1)(n+1)})]. \tag{11}$$

By substitution of t_n from equation 11 in equation 3 and rewriting, we may calculate the thickness of any layer,

$$h_n = t_n V_n. \tag{12}$$

Application

Refraction times are picked on the seismograms to the nearest millisecond and the values plotted on graph paper against the corresponding geophone distances. The branches are determined by fitting a series of straight lines through the points. Here, the experience of the computer and a general knowledge of the local geology are invaluable for obtaining the best interpretation of the data.

Velocities are obtained from the reciprocals of the slopes of the straight-line branches, and the intercepts are found by extrapolation to the time-axis.

The numerical evaluation of equations 10, 11 and 12 is carried out on printed computation forms such as shown in Tables 1, 2 and 3. A special K-scale, made by plotting the values of K for a series of values of the ratio $\frac{V_i}{V_j}$ against the CF-scale of a Log-Log Duplex or similar-type slide rule, is used to compute t and T directly from the velocity ratios and the intercepts. The location of the special scale is shown in Fig. 2.

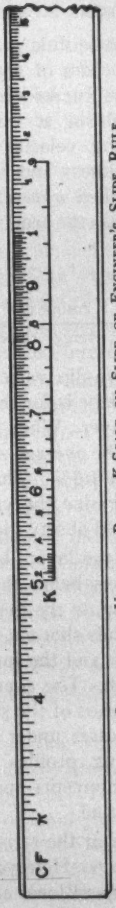

FIG. 2.—LOCATION OF VELOCITY-RATIO *K*-SCALE ON SLIDE OF ENGINEER'S SLIDE RULE.

Use of the Method Where Layers are Not Horizontal

It is customary to shoot seismic profiles from both ends of the geophone spread. If the velocities of corresponding branches of the oppositely directed travel-time curves are equal, it may be assumed that the layers are horizontal (or at least parallel to the surface). If, however, the corresponding velocity values are not equal, the refracting layers vary in thickness and the reciprocals of the slopes of the curve branches are called *apparent velocities*. The relations between the apparent velocities, the true velocity and the dip for one inclined layer are

$$V_d < V_2 < V_u \tag{13}$$

and

$$V_2 = \frac{\text{cosine dip}}{\text{average slope}} \tag{14}$$

where V_d is the apparent down-dip velocity and V_u is the apparent up-dip velocity. The average slope is for the up-and down-dip branches of the velocity in the second layer. When the angle of dip is less than 10°, the error in using simply the average slope as the reciprocal of the true velocity will be less than 1.5%. Therefore, for most work the average slope is used to determine the value of the velocity and is accurate within the limits of field observation.

Either the thicknesses of the layers below the shot points or the average thicknesses of the layers below the center of the spread may be computed. In order to compute the average thicknesses below the shot point, the data for all spreads shot out of the same hole are plotted on the same set of coördinates, and the intercepts and average slopes are determined from the graph. The computations are then carried on in the routine manner by means of the slide rule and regular forms. To obtain the average thicknesses under the center of the spreads, the data from the interlocking profiles are plotted on the same coördinates, and the average intercepts and slopes are determined on the graph. Computation is routine.

It should be remembered that the refraction depths computed are normal to the refracting horizon. However, for small angles of dip the difference is less than the operational error and it is customary to use the computed values as vertical depths or thicknesses.

Accuracy of the System

In practice there are several possible sources of error. The allowable variation in reading a seismogram is plus or minus one millisecond on any individual pick. This error might be reduced by increasing the paper speed in the camera, and by obtaining sharper breaks by changes in instruments or charges. However, the reduction of error by such refinements might well be masked by irregularities, caused by the lack of homogeneity of the layers.

Errors in fitting straight lines to the data might be minimized by a least-square adjustment, but the slight improvement over the values obtained by the sight-fitting of an experienced computer would not justify the effort. The most serious effect of error in fitting the line to the points lies not in the determination of the velocities, but in the determination of the extrapolated intercept.

One possible source of error inherent in this system lies in the computation of the table of constants (Table 4). This source may be eliminated by computing the values for smaller differences in the velocity ratio and by performing the calculations by machine. However, the slide rule is consistent with the accuracy maintained with respect to other sources of error.

With reasonable care, the first intercept should be accurate within plus or minus half a millisecond, since it is an average value. The second intercept should be correct within plus or minus one millisecond. Other intercepts will have greater possible errors, depending to some extent upon the ratio of the length of the observed branch to the distance of the data from the abscissa. Nevertheless, as the intercept becomes greater with depth, the percentage error may remain the same or even decrease.

The allowable error in passing a straight line through the plotted time-distance data does not allow determination of the velocities closer than to the nearest 100 ft per sec. Therefore the velocity ratio need not be carried beyond two decimal places. In areas where the ratios are of the order of 0.70, it might be well to compute the constants for intermediate values and obtain finer divisions on that part of the slide-rule scale. The values presented have been found satisfactory in drift areas of Michigan and Illinois.

By assuming a velocity distribution consistent with the data presented by Linehan and Keith for New England, we may investigate the amount of discrepancy to be expected between calculated and drilled thicknesses. If we assume $V_1 = 2{,}000$ ft per sec, $V_2 = 6{,}000$ ft per sec and $V_3 = 20{,}000$ ft per sec, the error in the computed thickness of the first layer, measured in feet, will essentially equal the error in I_1, measured in milliseconds. The error in the thickness of the second layer will be about three feet for each millisecond error in I_2. The carry-over effect of an error in observation of I_1 upon the thickness h_2 will be about two-thirds of the percentage error in h_1. For example, if h_1 is in error by 5%, then h_2 will be in error by 3.3%.

If plus or minus one millisecond is used for I_1, and plus or minus two milliseconds for I_2, the discrepancies will be of the same order as reported by Linehan and Keith—*i.e.*, about 5 ft in 100 ft of total depth.

BOOK REVIEWS

The writer has had occasion recently to read in whole or in part three interesting but quite different books. Members of the New England Water Works Association may well find it advantageous to be informed, at least in a general way, of their contents.

The *Manual of British Water Supply Practice*, published by the Institution of Water Engineers in 1950, is a volume of some 910 pages. In the preparation of the Manual, some 86 authors took an active part, and 77 collaborators gave assistance and advice. The work of all these individuals was directed, coördinated and edited by the late A. T. Hobbs, who was Secretary of the Institution from 1925 until his death in 1950.

The scope of the Manual is indicated by the wide range of water-supply subjects dealt with, including historical development, hydrology, hydrogeology, hydraulics, sources of supply, reservoirs, pumping stations, distribution systems, water treatment and purification, analytical examinations, as well as legal, financial and management matters. Although British practice deviates in details from American practice, the fundamental principles of water-supply engineering are of general application. Naturally, some of the chapters are of more value and interest to American engineers than are others, but the book as a whole is well worth the current price of $7.50.

Those members of the Association who heard or read the paper by Lincoln W. Ryder upon "The Case for Water Witching", published in this JOURNAL for September, 1949, would be interested to read Kenneth Roberts' entertaining book, *Henry Gross and His Dowsing Rod*. The claims made for the dowsing rod and Roberts' theory of "domes and veins" as sources of ground-water supply are amazing, to say the least.

In this connection, the following quotation from the *Manual of British Water Supply Practice* is significant:

> "The general consensus of opinion among water engineers throughout the world is that dowsing has little to recommend it."

The Water Seekers by Remi Nadeau, published in 1950, has no relation to water witching, but is a fascinating account of the struggles between the ranchers and the city of Los Angeles for the waters of the Owens Valley, and of the long-drawn-out legal and political battles between California and a half dozen or more other states for the Colorado River water. For those aware of the greater and greater demands upon the water resources of the country, this book presents in vivid form the bitter battles, physical and legal, waged for water in southwestern United States.

E. SHERMAN CHASE

PROCEEDINGS

JANUARY 1951 MEETING
HOTEL STATLER, BOSTON, MASS.
THURSDAY, JANUARY 18, 1951

President Thomas R. Camp in the Chair.

Secretary Knox announced the election of the following to membership in the Association:

Samuel J. Bargh, American Water Works Service Co., Islington, Mass.; Joseph M. Farnham, Jr., Superintendent, Water Department, Essex, Mass.; Harry R. Feldman, Civil Engineer, Harry R. Feldman Engineering Service Co., Watertown, Mass.; William G. Hartwell, Superintendent and Treasurer, Anson Water District, Anson, Me.; Philip W. Sheridan, Jr., Design Engineer, Tighe & Bond, Holyoke, Mass.

Reinstated

William D. Smith, Johns-Manville Co., Springfield, Mass.

Associate Member

Curry Oil Co., Boston, Mass.

A paper on "Recent Surveys in Connecticut of Water Piping within Buildings" was read by Charles H. Lawrence, Sanitary Engineer, Bureau of Sanitary Engineering, State Department of Health, Hartford, Conn.

A paper on "Factors Influencing the Efficiency of Activated Carbon" was read by Al Y. Hyndshaw, Research Chemist, West Virginia Pulp and Paper Co., Tyrone, Pa.

A paper on "Natural-Resources Survey of New England and New York" was read by Col. Harry L. Fox, Executive to the Chairman, New England-New York Inter-Agency Committee, Corps of Engineers, U. S. Army, Boston, Mass.

FEBRUARY 1951 MEETING
HOTEL STATLER, BOSTON, MASS.
THURSDAY, FEBRUARY 15, 1951

President Thomas R. Camp in the Chair.

Secretary Knox announced the election of the following to membership in the Association:

Lendon F. Dutton, Superintendent, Department of Utilities, Groton, Conn.; Angus D. Henderson, Engineering Manager, Hydrotechnic Corp., New York, N. Y.; I. Laird Newell, Consulting Engineer, Henry Souther Engineering Co., Hartford, Conn.; Rostislaff Nebolsine, Consulting Engineer, New York, N. Y.; Wallace S. Pinkham, Engineer, Water Works, Tisbury, Mass.

A paper on "Factors Affecting the Yield of Rock Wells in Southern New England" was presented by Robert V. Cushman, Geologist in Charge, U. S. Geological Survey, Middletown, Conn.

A talk, entitled "Notes on English Water Works," was presented by Charles Y. Hitchcock, Project Engineer, Metcalf & Eddy, Boston, Mass.

A paper on "Treating Algae under the Ice at Westfield, Massachusetts" was presented by Ernest A. Snow, Jr., Senior Chemist, Massachusetts Department of Public Health, University of Massachusetts, Amherst, Mass.

MARCH 1951 MEETING
HOTEL STATLER, BOSTON, MASS.
THURSDAY, MARCH 15, 1951

President Thomas R. Camp in the Chair.

Secretary Knox announced the election of the following to membership:

Dwight L. Agnew, Manager, Scituate, Cohasset and Hingham Water Companies, Hingham, Mass.; Edward D. Barton, Superintendent, Water Works, Lowell, Mass.; James C. Callahan, Com-

missioner of Water Supply, Lynn, Mass.; John J. Coleman, President and Treasurer, Allied Engineering Corp., Roxbury, Mass.; Thomas T. Craven, Sales Manager, New England District, Warren Pipe Co. of Massachusetts, Inc., Boston, Mass.; William E. Dobbins, Associate Professor of Sanitary Engineering, New York University, New York, N. Y.; Harold L. Garland, Foreman, Water Supply District, Dracut, Mass.; George F. Gay, in Charge of Maintenance, Water Department, Stoughton, Mass.; Richard P. Grossman, Senior Sanitary Engineer, New Hampshire Dept. of Health, Manchester, N. H.; Clarence R. Hall, Superintendent, Water Department, Dover, N. H.; Fortis E. Hart, Superintendent, Water Department, Littleton, Mass.; Dwight A. Hogg, District Manager, Lock Joint Pipe Co., West Hartford, Conn.; Stanley B. Johnson, New England Sales Manager, Mueller Co., Wellesley, Mass.; Christian G. Kuehlke, Jr., Assistant Manager, Ansonia Water Co., Ansonia, Conn.; George L. Legg, Superintendent, Water Department, Hanover, Mass.; Joseph G. Lufkin, President, Red Hed Manufacturing Co., Boston, Mass.; Charles K. Moore, Civil Engineer, U. S. Army Engineers, Swansea, Mass.; Louis Neleber, Superintendent, Water Works, Colchester, Conn.; John S. O'Reilly, New England Sales Manager, Hersey Manufacturing Co., Boston, Mass.; Peter F. Riopelle, Assistant Superintendent, Water Department, Lowell, Mass.; Amedee F. Roy, Superintendent, Water Department, Ashburnham, Mass.; Sumner Smith, Chairman, Board of Water Commissioners, Lincoln, Mass.; Leo Trudelle, Superintendent, Water District, Swansea, Mass.; Henry Warner, Member, Board of Water Commissioners, Lincoln, Mass.; John A. Morley, Pittsburgh-Des Moines Steel Co., Westfield, N. J.; John K. Kirn, Johnson Plastic Corp., Marblehead, Mass.

Associate Member

Johnson Plastic Corp., Chagrin Falls, O.

PRESIDENT CAMP. Your Legislative Committee has been active. Mark Croker is chairman. I should like to have him say a few words.

MARK F. CROKER. I shall report briefly on the bills being heard by the Committees of the Massachusetts Legislature which are of general interest to the members of this Association.

House 974 is an act to authorize the levying of special assessments for laying water pipes in public ways. That was heard by the Committee on Municipal Finance last Tuesday morning. This petition was introduced a year ago and passed by both Senate and House. It reached the Governor's desk and was then withdrawn and held in the Senate. The hearing last Tuesday was covered by your Legislative Committee and the Association recorded itself in favor of the passage of this legislation.

Yesterday morning hearings were held by the Committee on State Administration on Senate 484 and House 1473. Senate 484 is an act clarifying the statute regulating competitive bidding on public-works projects; and House 1473 is an act further regulating plans, specifications and bids on construction, reconstruction, alteration, remodeling or repairing of certain public works. Senate 484, which your Committee was prepared to oppose, was withdrawn by the petitioner, Francis J. Sullivan, and he gave his support to House 1473. This bill developed strong opposition and the opinion is that the Committee will submit an adverse report. Incidentally, in reference to Senate 484, while your committee makes no claim of infallibility as regards the detection of proposed legislation, it may be of interest to the members of the Association that your committee was the first among the interested agencies to be aware of this hearing.

House 1472 is an act relative to furnishing of performance bonds in contracts for public works and to fair competition for bids on construction, reconstruction, alteration, remodeling or repair of certain public works by the Commonwealth or any political subdivision thereof. Hearing on this proposed legislation has been postponed until next week. I understand that in the meantime the proponent of the bill is to make some slight change in it, which will improve it as far as the water-works men are concerned. That is before State Administration.

House 80 is an act relative to the furnishing of water to towns in the Metropolitan Water District. That is to be heard on Monday, March 19, in Room 207 at 10.30, before the Committee on Metropolitan Affairs.

House 2143, Special Report of the Department of Public Health, authorized to make an investigation and study relative to the ground-

water supply and its use and protection within the Commonwealth, together with the proposed legislation which goes with it, is listed on the legislative bulletin under bills to be heard by the Committee on Water Supply. The hearing date has not yet been scheduled.

House 1698 relates to the proposed establishment of an unpaid commission, consisting of the Commissioner of Conservation, the Commissioner of Agriculture and the Commissioner of Public Health, for the purpose of holding hearings regarding the creation of a weather-amendment board, for the purpose of controlling the alteration of weather by human or artificial means. This proposed legislation is now under consideration by the Committee on Ways and Means.

* * * *

Upon motion by Warren J. Scott, duly seconded, it was VOTED that the following be appointed as a Nominating Committee: Harold W. Griswold, Chairman, Horace L. Clark, Karl R. Kennison, Arthur L. Shaw and Donald C. Calderwood.

A paper on "The Civil Defense of New England" was read by Albert D. O'Connor, Northeastern States Regional Director of the Federal Civil Defense Administration. This was followed by a panel discussion on "Water-Supply Planning for Civil Defense," the panel consisting of the following:

Warren J. Scott, Director, Bureau of Sanitary Engineering, State Department of Health, Hartford, Conn.; Howard H. Potter, Maine Public Utilities Commission, Augusta, Me.; Clarence I. Sterling, Jr., Chief Engineer, Massachusetts Department of Public Health, Boston, Mass.; Frank J. Lariviere, Division of Sanitary Engineering, New Hampshire Department of Health, Concord, N. H.; Walter J. Shea, Chief Engineer, Rhode Island Department of Health, Providence, R. I.; Edward L. Tracy, Director, Division of Sanitary Engineering, Vermont Department of Health, Burlington, Vt.; Earl Devendorf, Director of Environmental Sanitation, State Department of Health, Albany, N. Y., and Gordon E. McCallum, Sanitary Engineer, U. S. Public Health Service, Federal Security Agency, Washington, D. C.

Some official films of the U. S. Public Health Service, illustrating the medical aspects of atomic explosions, were shown.

INDEX OF ADVERTISERS

	Page
Atlas Mineral Products Co.	xxvi
Badger Meter Mfg. Co.	Following front cover
Bailey, Howard E.	ii
Brown Company	ix
Builders-Providence, Inc. Division of Builders Iron Foundry	xvi
Camp, Thomas R.	ii
Cast Iron Pipe Research Assn.	xxxiii
Cement Lined Pipe Co.	iii
Centriline Corporation	Following front cover
Chapman, R. E.	ii
Chemical Fire & Rust Proofing Corp.	xxvi
Eddy Valve Co.	xix
Eureka Pipe Co., Inc.	xxvi
Fairbanks-Morse Co.	xi
Fay, Spofford & Thorndike	ii
Flexible Sewer Rod Equipment Co.	xxii
Ford Meter Box Co.	Following front cover
Gunite Restorator	ii
Haley & Ward	ii
Hays Mfg. Co.	xvii
Hersey Mfg. Co.	iv
Hilco Supply	xv
Hughes, Edward F., Co.	iii
Hydraulic Development Corp.	x
Johns-Manville	Following front cover
Keasbey & Mattison Company	xxviii
Kennedy Valve Mfg. Co.	xiii
Knowles, Morris, Inc.	ii
Koppers Company, Inc.	Following front cover
Layne-New York Co., Inc.	iii
Leadite Co.	Back cover
Leggette, R. M.	ii
Lock Joint Pipe Co.	Following front cover
Maher, D. L., Co.	iii
Metcalf & Eddy	ii
Morris Machine Works	xviii
Mueller Co.	Following front cover
National Water Main Cleaning Co.	viii
Neptune Meter Co.	vii
Northrop & Co.	ix
Omega Machine Co. (Division of Builders Iron Foundry)	xxi
Pierce-Perry Co.	iii
Pipe Founders Sales Corp.	xxii
Pirnie, Malcolm	iii
Pitometer Co.	iii
Pittsburgh Equitable Meter Co.	Following front cover
Joseph G. Pollard Co., Inc.	xv
H. R. Prescott & Sons	ix
% Proportioneers, Inc. %	Following front cover
Red Hed Mfg. Co.	v
Rensselaer Valve Co.	xxvii
Reppucci, C. & Sons, Inc.	iii
Ross Valve Mfg. Co.	xxiii
Smith Mfg. Co., The A. P.	Following front cover
Turbine Equipment Co.	xiv
U. S. Pipe and Foundry Co.	xxxiv
Utilities Supply	xxii
Wallace & Tiernan	xx
Warren Foundry and Pipe Corp.	xxi
Welsbach Corporation	xxv
Weston & Sampson	iii
Whitman & Howard	iii
Wood, R. D., Co.	Following front cover
Worthington Pump and Machinery Corp.	vi

(Classified index on page xxix)

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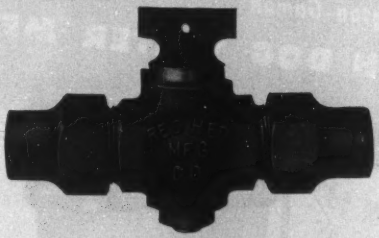

Fig. 415

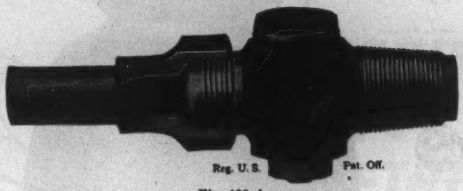

Fig. 438-A

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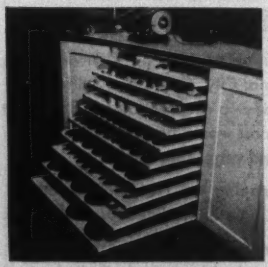

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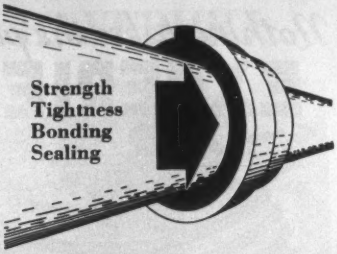

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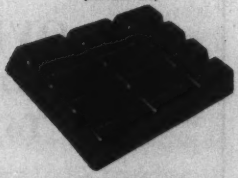

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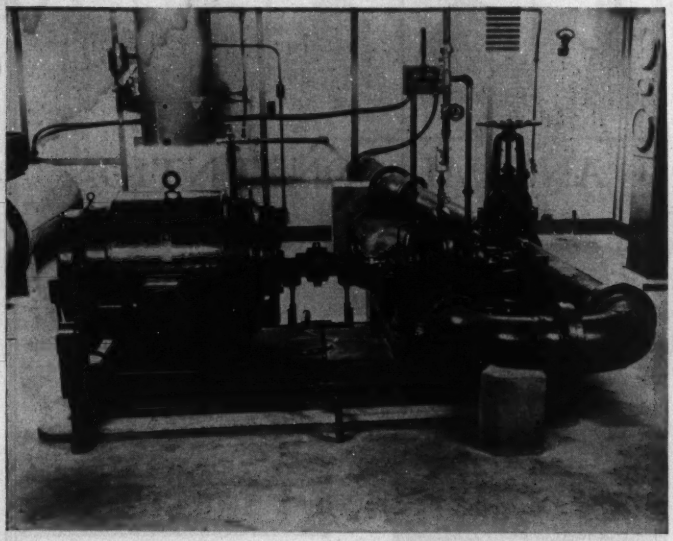

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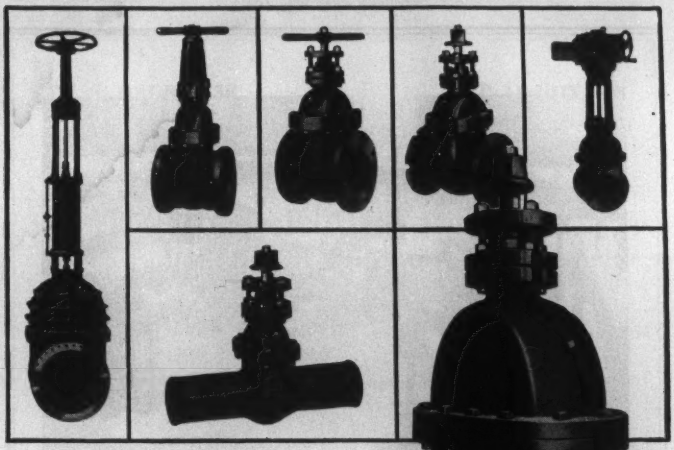

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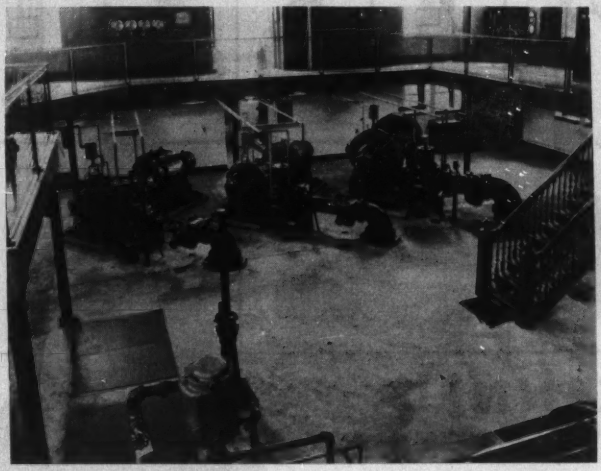

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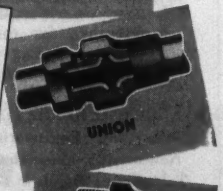

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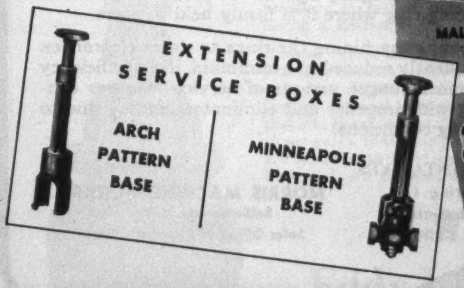

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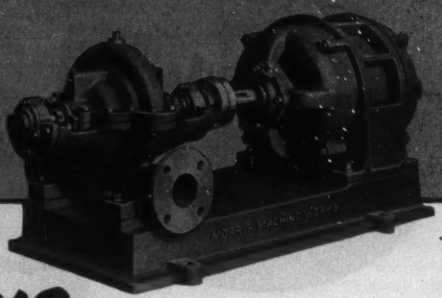

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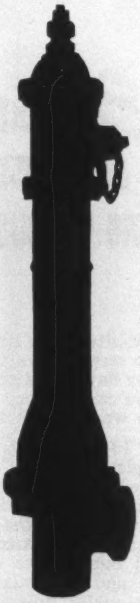

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ONLY three parts are moved by the Stem—the ball and the two gates. Each gate is hung from one of the trunnions on the ball. A convex surface at the base of each trunnion fits a concave surface on the back of the gate. This allows the gates to adjust themselves properly to their seats. . . . The gates, being free to revolve on the trunnions, do not always seat in the same position. Gates are center bearing and adjustable. They are forced to their seats with equal pressure at all points. There are two hooks on the ball on sizes 4-inch and larger, which loosely engage with the gates.

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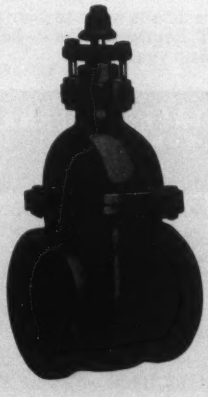

. . . To raise the hydrant to conform to a new grading, simply insert a flanged extension piece below the swivelhead. No digging. To add a steamer nozzle at any time, it is only necessary to replace the swivel head with one having a steamer nozzle.

Besides valves and hydrants to meet the most exacting demands of waterworks service, the complete EDDY Line includes: valves for sewage disposal works; valves for steam, gas and oil; check valves, foot valves, plug valves, shear gates, indicator posts, etc. EDDY valves are made in three classes: Iron Body Bronze Mounted, All Bronze, and All Iron Valves.

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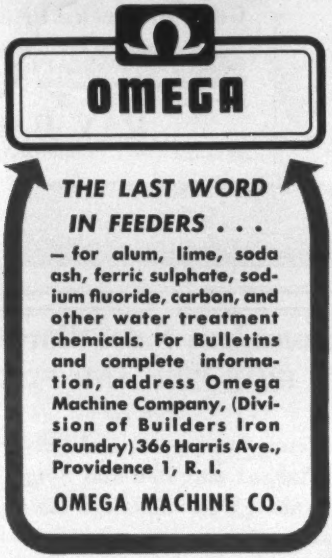
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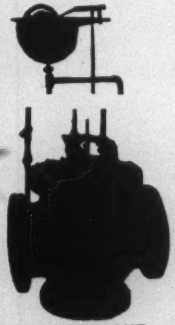

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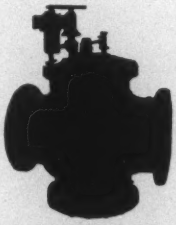

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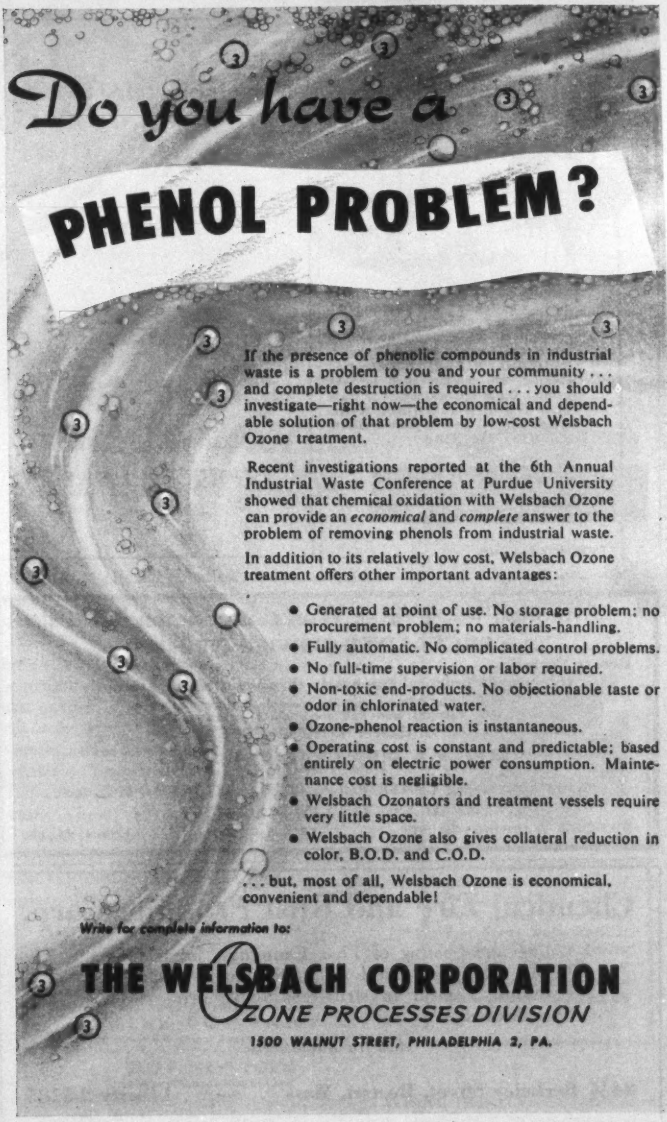
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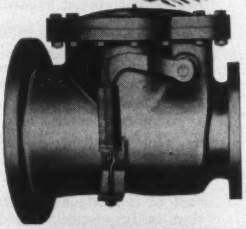

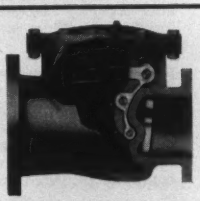

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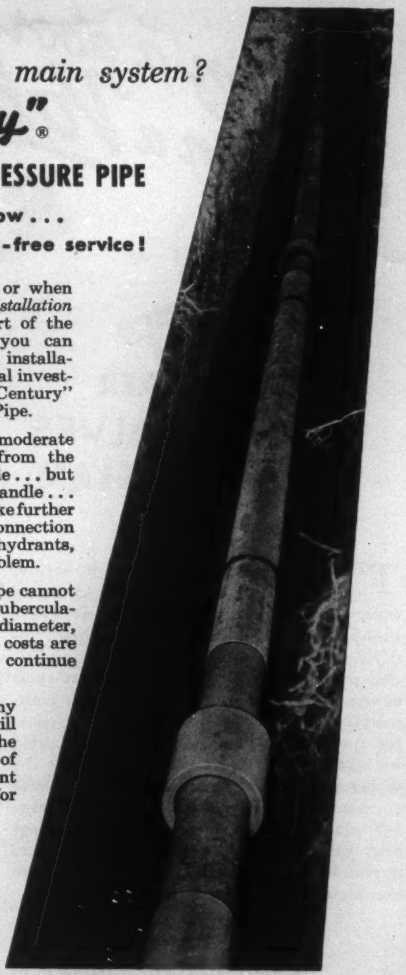

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ASBESTOS-CEMENT PIPE.
Keasbey & Mattison Company xxviii

BRASS GOODS.
Eureka Cement Lined Pipe Co. xxvi
Hays Mfg. Co. xvii
Hilco Supply xv
Mueller Co. ..... Following front cover
Pierce-Perry Co. iii
Red Hed Mfg. Co. v
Smith Mfg. Co., The A. P. ..... Following front cover

CALKING MACHINERY AND TOOLS.
Hydraulic Development Corp. x
Mueller Co. ..... Following front cover
Northrop & Co. ix

CAST IRON PIPE. (See Pipe, Cast Iron)

CEMENT LINED PIPE. (See Pipe, Cement Lined.)

CHEMICAL FEED APPARATUS.
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xvi
Omega Machine Co. (Division of Builders Iron Foundry) xxi
% Proportioneers, Inc. % ..... Following front cover
Wallace & Tiernan Co., Inc. xx

CHLORINATORS.
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xvi
% Proportioneers, Inc. % ..... Following front cover
Wallace & Tiernan Co., Inc. xx

CLEANING WATER MAINS.
Flexible Underground Pipe Cleaning Co. xxii
National Water Main Cleaning Co. viii

COCKS, CURBS AND CORPORATIONS.
Eureka Cement Lined Pipe Co. xxvi
Hays Mfg. Co. xvii
Mueller Co. ..... Following front cover
Pierce-Perry Co. iii
Smith Mfg. Co., The A. P. ..... Following front cover

CONCRETE PIPE. (See Pipe, Concrete.)

CONTRACTORS' EQUIPMENT.
Hydraulic Development Corp. x
Northrop & Co. ix

COUPLINGS, FLEXIBLE PIPE
Johns-Manville ..... Following front cover

CONTRACTORS.
Layne-New York Co. iii
Maher, D. L. Co. iii
Reppucci, C. & Sons iii

CURB BOXES.
Eureka Cement Lined Pipe Co. xxvi
Hays Mfg. Co. xvii
Hilco Supply xv
Mueller Co. ..... Following front cover
Pierce-Perry Co. iii
H. R. Prescott & Sons ix

DIAPHRAGMS, PUMPS.
% Proportioneers, Inc. % ..... Following front cover

ENGINEERS.
Bailey, Howard E. ii
Camp, Dresser and McKee ii
Fay, Spofford and Thorndike ii
Haley and Ward ii
Knowles, Morris, Inc. ii
Metcalf and Eddy ii
Pirnie Engineers, Malcolm iii
Weston and Sampson iii
Whitman and Howard iii

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

ENGINES. (See Pumps and Pumping Engines.)

EQUIPMENT. (See Contractors' Equipment.)

FEED WATER FILTERS.
- % Proportioneers, Inc. %.....Following front cover
- Ross Valve Mfg. Co., Inc.....xxiii

FILTRATION PLANT EQUIPMENT.
- Builders-Providence, Inc. (Divn. of Builders Iron Fdry.).....xvi
- % Proportioneers, Inc. %.....Following front cover

FLAP VALVES.
- Eddy Valve Co.....xix

FLEXIBLE JOINTS.
- U. S. Pipe and Foundry Co.....xxxiv

FURNACES.
- Hilco Supply.....xv
- Hydraulic Development Corp.....x
- Leadite Co., The.....Back cover
- Mueller Co.....Following front cover
- Northrop & Co.....ix
- Pollard Co., Joseph G.....xv
- H. R. Prescott & Sons.....ix

GATE VALVES. (See Valves.)

HOSE, SUCTION AND CONDUCTION.
- H. R. Prescott & Sons.....ix

HYDRANTS, FIRE.
- Eddy Valve Co.....xix
- Hilco Supply.....xv
- Kennedy Valve Mfg. Co.....xiii
- Mueller Co.....Following front cover
- H. R. Prescott & Sons.....ix
- Rensselaer Valve Co.....xxvii
- Smith Mfg. Co., The A. P.....Following front cover
- Wood, R. D., Co.....Following front cover

HYDRANTS, PUMPS.
- Hilco Supply.....xv
- H. R. Prescott & Sons.....ix

LEAD PIPE. (See Pipe, Lead.)

LIQUID CHLORINE.
- Brown Co.....ix

METERS, OIL AND WATER.
- Badger Meter Mfg. Co.....Following front cover
- Builders-Providence, Inc. (Divn. of Builders Iron Fdry.).....xvi
- Hersey Mfg. Co.....iv
- Neptune Meter Co.....vii
- Pipe Founders Sales Corp.....xxii
- Pittsburgh Equitable Meter Divn.....Following front cover
- Worthington-Gamon Meter Co.....vi

METER COUPLINGS.
- Badger Meter Mfg. Co.....Following front cover
- Ford Meter Co.....Following front cover
- Hays Mfg. Co.....xvii
- Hersey Mfg. Co.....iv
- Mueller Co.....Following front cover
- Neptune Meter Co.....vii
- Red Hed Mfg. Co.....v
- Smith Mfg. Co., The A. P.....Following front cover
- Worthington-Gamon Meter Co.....vi

METERS (Venturi Type.)
- Builders-Providence, Inc. (Divn. of Builders Iron Fdry.).....xvi

METER BOXES.
- Ford Meter Co.....Following front cover
- Mueller Co.....Following front cover

METER TESTERS.
- Badger Meter Mfg. Co.....Following front cover
- Ford Meter Co.....Following front cover
- Mueller Co.....Following front cover
- Neptune Meter Co.....vii

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

OIL ENGINES.
Fairbanks, Morse Co. ... xi

OZINATION EQUIPMENT.
Welsbach Corp. ... xxv

PIPE, ASBESTOS-CEMENT
Johns-Manville ... Following front cover
Keasbey & Mattison Company ... xxviii

PIPE, BRASS.
Hilco Supply ... xv
Pierce-Perry Co. ... iii
H. R. Prescott & Sons ... ix

PIPE, CAST IRON (and Fittings.)
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) ... xvi
Cast Iron Pipe Research Association ... xxxiii
Hilco Supply ... xv
Pipe Founders Sales Corp. ... xxii
H. R. Prescott & Sons ... ix
U. S. Cast Iron Pipe and Foundry Co. ... xxxiv
Warren Foundry and Pipe Co. ... xxi
Wood, R. D., Co. ... Following front cover

PIPE, CEMENT LINED.
Cast Iron Pipe Research Association ... xxxiii
Cement Lined Pipe Co. ... iii
Eureka Cement Lined Pipe Co. ... xxvi
Pipe Founders Sales Corp. ... xxii
U. S. Cast Iron Pipe and Foundry Co. ... xxxiv

PIPE, COATING AND LININGS.
Centriline Corp. ... Following front cover
Koppers Company, Inc. ... Following front cover

PIPE, CONCRETE.
Lock Joint Pipe Co. ... Facing front cover

PIPE CUTTING MACHINES.
Pollard Co., Joseph G. ... xv
Smith Mfg. Co., The A. P. ... Following front cover

PIPE JOINTING MATERIAL.
Atlas Mineral Products Co. ... xxvi
Hilco Supply ... xv
Hydraulic Development Corp. ... x
Leadite Co., The ... Back cover
Northrop & Co. ... ix

PIPE, LEAD.
Pierce-Perry Co. ... iii
Red Hed Mfg. Co. ... v

PIPE LINING.
Centriline Corp. ... Following front cover

PIPE, PRESTRESSED CONCRETE.
Lock Joint Pipe Co. ... Facing front cover

PIPE, WROUGHT IRON AND STEEL
Pierce-Perry Co. ... iii

PLUG VALVES.
Eddy Valve Co. ... xix
Hays Mfg. Co. ... xvii
Mueller Co. ... Following front cover
Pittsburgh Equitable Meter Divn. ... Following front cover

PITOMETERS.
Pitometer Co., Engrs. ... iii

PORTABLE AIR COMPRESSORS. (See Air Compressors.)

PRESSURE REGULATORS.
Hilco Supply ... xv
Mueller Co. ... Following front cover
Pittsburgh Equitable Meter Divn. ... Following front cover
H. R. Prescott & Sons ... ix
Ross Valve Mfg. Co., Inc. ... xxiii

PROVERS, WATER.
Badger Meter Mfg. Co. ... Following front cover

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

PUMPS AND PUMPING MACHINES.
- Fairbanks, Morse and Co. ... xi
- Layne-New York Co., Inc. ... iii
- Hilco Supply ... xv
- Maher Co., D. L. ... iii
- Morris Machine Works ... xviii
- H. R. Prescott & Sons ... ix
- Ross Valve Mfg. Co., Inc. ... xxiii
- Turbine Equipment Co. ... xiv

RATE CONTROLLERS AND GAUGES.
- Badger Meter Mfg. Co. ... Following front cover
- Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) ... xvi

SHEAR GATES.
- Eddy Valve Co. ... xix
- Mueller Co. ... Following front cover

SLEEVES AND VALVE TAPPINGS.
- Eddy Valve Co. ... xix
- Hilco Supply ... xv
- Mueller Co. ... Following front cover
- H. R. Prescott & Sons ... ix
- Rensselaer Valve Co. ... xxvii
- Smith Mfg. Co., The A. P. ... Following front cover

SUPPLIES AND TOOLS.
- Hilco Supply ... xv
- Hydraulic Development Corp. ... x
- Leadite Co., The ... Back cover
- Mueller Co. ... Following front cover
- Northrop & Co. ... ix
- Pierce-Perry Co. ... iii
- Pollard Co., Joseph G. ... xv
- H. R. Prescott & Sons ... ix

TAPPING MACHINES.
- Hays Mfg. Co. ... xvii
- Mueller Co. ... Following front cover
- Red Hed Mfg. Co. ... v
- Smith Mfg. Co., The A. P. ... Following front cover

TAPPING SLEEVES. (See Slecves and Valves, Tappings.)

VALVE BOXES.
- Eddy Valve Co. ... xix
- Hilco Supply ... xv
- Kennedy Valve Mfg. Co. ... xiii
- Mueller Co. ... Following front cover
- Pierce-Perry Co. ... iii
- Pipe Founders Sales Corp. ... xxii
- H. R. Prescott & Sons ... ix
- Smith Mfg. Co., The A. P. ... Following front cover
- Wood, R. D., Co. ... Following front cover

VALVE INSERTING MACHINES.
- Mueller Co. ... Following front cover
- Smith Mfg. Co., The A. P. ... Following front cover

VALVES, CHLORINE.
- Wallace & Tiernan Co., Inc. ... xx

VALVES, GATE.
- Eddy Valve Co. ... xix
- Hilco Supply ... xv
- Kennedy Valve Mfg. Co. ... xiii
- Mueller Co. ... Following front cover
- Pierce-Perry Co. ... iii
- H. R. Prescott & Sons ... ix
- Rensselaer Valve Co. ... xxvii
- Smith Mfg. Co., The A. P. ... Following front cover
- Wood, R. D., Co. ... Following front cover

VALVES, REGULATING.
- Mueller Co. ... Following front cover
- Ross Valve Mfg. Co., Inc. ... xxiii

WATER WASTE DETECTION.
- Pitometer Co., The ... iii

WELL CONNECTIONS.
- Red Hed Mfg. Co. ... v

WELLS, GRAVEL, FILTER AND DRIVEN.
- Edward F. Hughes Company ... iii
- Maher Co., The D. L. ... iii

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